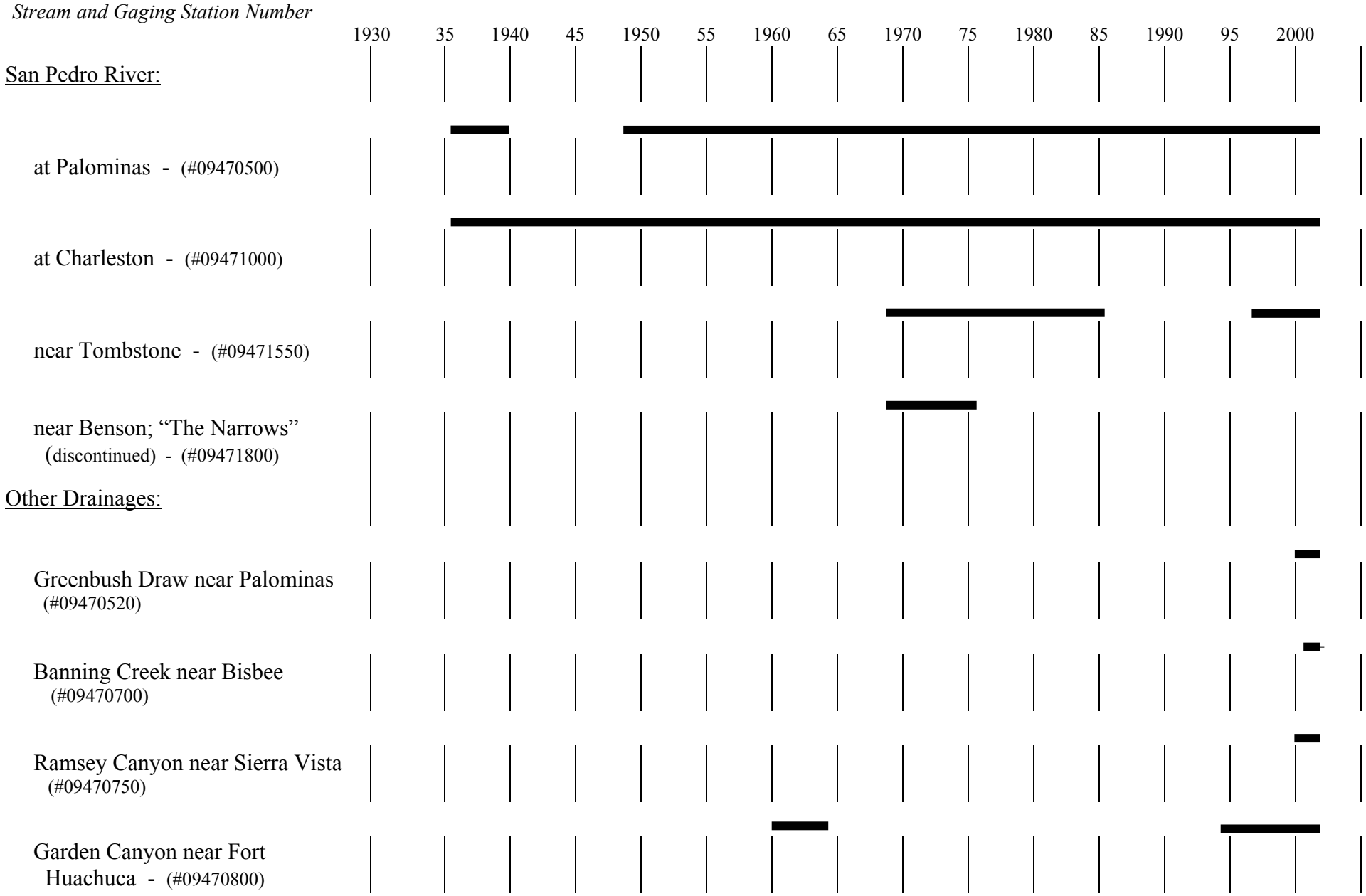
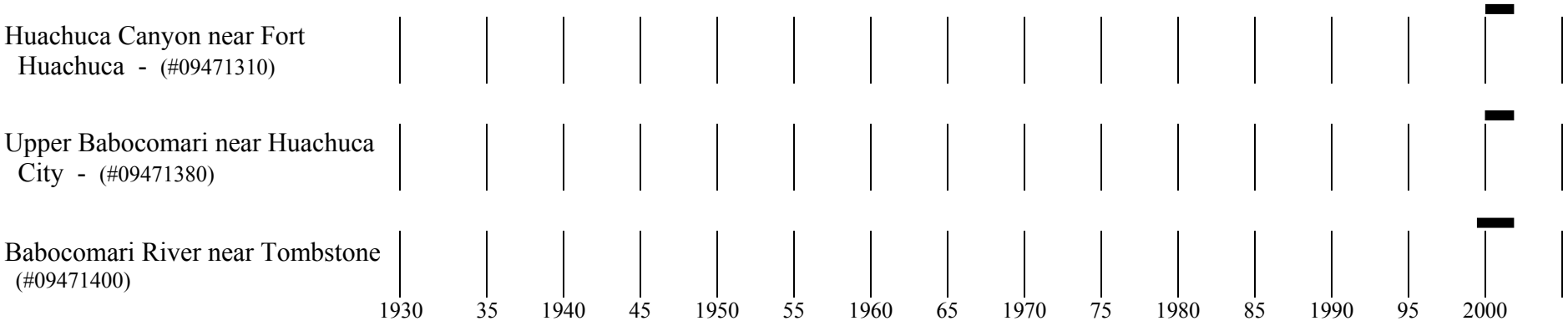
APPENDIX A

APPENDIX A

Period of Record for USGS Stream Gaging Stations in the Upper San Pedro Basin



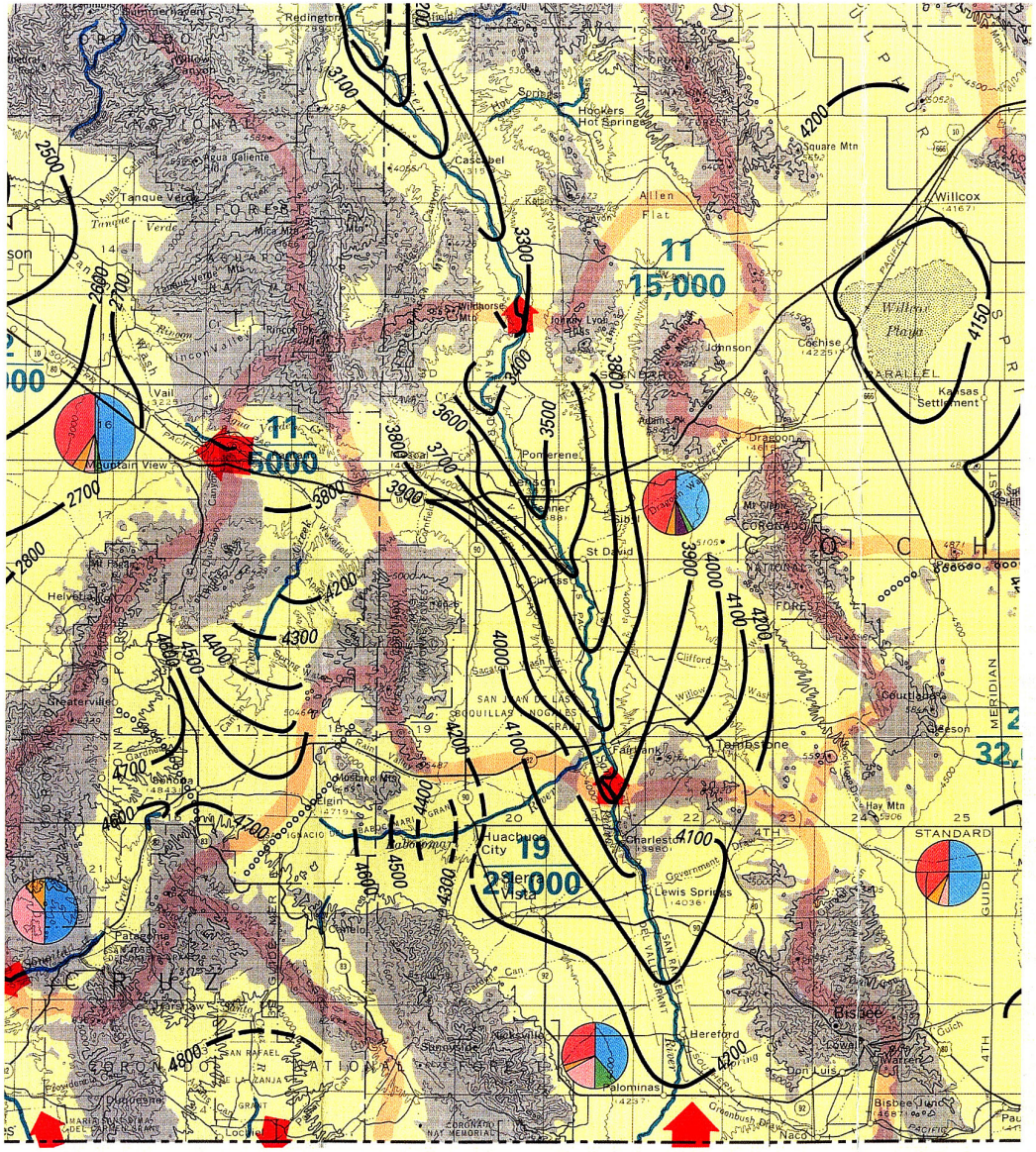


Source: U.S. Geological Survey, Water Resources Data, Arizona, Water Year 2001

APPENDIX B

APPENDIX B

Predevelopment Hydrologic Conditions in the Upper San Pedro Basin and Adjacent Basins



Source: Modified from Freethey and Anderson, 1986, Sheet 3.

4
11,000 RATIO OF ANNUAL INFLOW TO TOTAL VOLUME STORED IN THE GROUND-WATER SYSTEM—Upper number, 4, is the estimated average inflow and outflow to the aquifer of the basin, in thousands of acre-feet. Lower number, 11,000, is the estimated recoverable ground water in the basin-fill material to a depth of 1,200 feet below land surface, in thousands of acre-feet, rounded to the nearest million acre-feet

PERENNIAL STREAM

BOUNDARY OF GROUND-WATER BASIN

EXPLANATION

500 WATER-LEVEL CONTOUR—Shows altitude of the water level prior to development. Dashed where based on meager data; dotted where approximately located. Contour interval, in feet, is variable. National Geodetic Vertical Datum of 1929

1680 SELECTED WELL—Number, 1680, is water-level altitude measured prior to extensive development

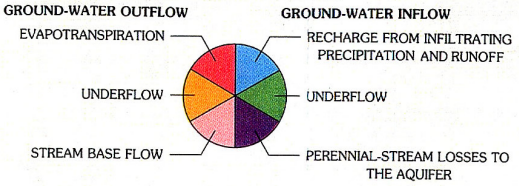
GROUND-WATER DIVIDE—Open circles where approximately located

BASIN-FILL DEPOSITS

BEDROCK OF THE MOUNTAINS

BASALT FLOWS—Overlie basin-fill deposits and may act as a confining layer

GROUND-WATER BUDGET



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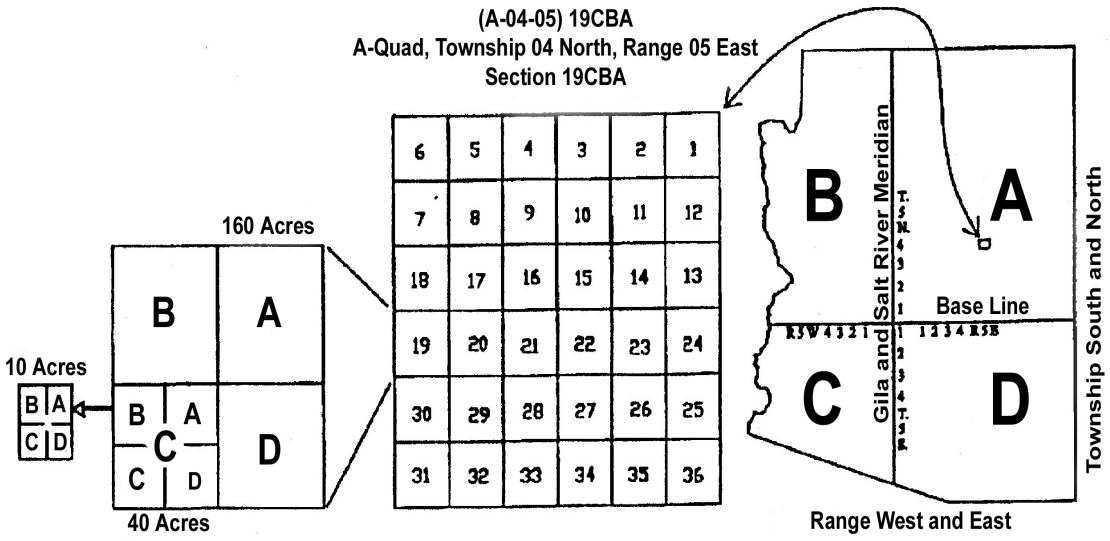
APPENDIX C

APPENDIX C

Well Numbering System

The well numbering system in Arizona is based on the Gila and Salt River baseline and meridian (GSRB&M) which divide the state into four quadrants. These quadrants are designated counter clockwise by the capital letters A, B, C, and D. All land north and east of the point of origin is in A quadrant, that north and west is in B quadrant, that south and west in C quadrant, and that south and east in D quadrant. The first digit of a well number indicates the township, the second the range, and the third the section in which the well is situated. The lowercase letters a, b, c, and d after the section number indicate the well location within the section. The first letter denotes a particular 160-acre tract, the second the 40-acre tract, and the third the 10-acre tract. These letters are also assigned in a counter clockwise direction, beginning in the north east quarter. If the location is known within the 10-acre tract, three lowercase letters are shown in the well number. In the example shown in Figure 8, well number (A-4-5) 19cba designates the well as being in the SW¼ NW¼ NE¼ Sec.19, T. 4 N., R. 5 E. Where there is more than one well within a 10-acre tract, consecutive numbers beginning with 1 are added as suffixes.

Well Numbering System in Arizona.



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APPENDIX D

APPENDIX D

ADWR Crop Survey of the Benson Sub-area, May 1 – 3, 2002

ADWR staff conducted a crop survey of the Benson sub-area from May 1st to May 3rd, 2002. The survey area extends from the St. David Irrigation District diversion north to the "Narrows" about 10 miles north of Benson. The survey area includes two surface water irrigation providers, St. David Irrigation District, Pomerene Water Users Association that divert water from the San Pedro River and non-district irrigation users in Benson and between Pomerene and the "Narrows."

The St. David Irrigation District (SDID) is located in and around the community of St. David. The SDID diversion is an earthen dam, which diverts the San Pedro River to acreage located on the east side of the San Pedro River. The district diverts water whenever flows in the river are sufficient for irrigation. The SDID operates two wells located about 1.5 miles north of the diversion. The wells provide supplemental water and they are used during periods when surface water is insufficient or unavailable to meet the District's needs. In addition, private wells are used to irrigate when surface water supplies are low. On May 1st, 2002 ADWR visited the SDID diversion and noted some water impounded by the dam. However, there was not enough water to be conveyed to the first field about 1.5 miles north. ADWR investigators observed an SDID well discharging water into the District's ditch and conveying water north towards St. David. The investigators also observed irrigators pumping from their private wells for irrigation on their properties.

The Pomerene Water Users Association (PWUA) service area includes the acreage east of the San Pedro River from the diversion and north several miles to Pomerene. The Association does not supplement surface water with well water because it does not own irrigation wells. Many individuals irrigate from their wells on their property, and a private well pumps into the PWUA canal to convey water to a portion of the system when surface water is unavailable. On May 2nd, ADWR visited the PWUA diversion and there was not enough water in the canal to reach the service area. Flowing water was observed in the canal near Pomerene but the source was not observed. Many individual irrigators were pumping from their wells to irrigate their fields.

Non-district irrigators in the Benson sub-area are located outside of the SDID and PWUA service areas. There are no surface water diversions by these irrigators and irrigation is supplied by well water.

ADWR staff identified and mapped survey area irrigation on the 1992 USGS Benson photo-quad, 1:10,560 scale and the 1996 USGS Galleta Flat East, Land and St. David photo-quads, 1:14,080 scale. The crop survey started at the first field along the SDID ditch approximately ½ mile north of the diversion and it was conducted systematically through St. David, Benson, Pomerene and up the San Pedro River to the "Narrows." Observations were recorded, mapped and some photographs and GPS locations were recorded in certain locations.

ADWR investigators examined agricultural and non-agricultural acreages supplied by surface water and wells in the Benson sub-area. Agricultural irrigation supplies water to farm crops in fields and there is non-agricultural irrigation of golf course and school yard turf, and landscapes associated with domestic use. Crops were identified, field conditions and irrigation delivery systems were observed, and the irrigation status was determined from on-site observations. Generally most property was accessible and observations were made as near the fields as possible. Some properties were posted "no trespassing" or gates were locked which limited access to fields. Also, some fields were surrounded by vegetation or were located far from entrance gates. Consequently some fields were observed from a distance but at the best possible vantage point. Lands that were not observed were not mapped.

ADWR determined that 5,707 acres can be irrigated with well water throughout the Benson sub-area and 2,407 of those acres can be irrigated with surface water from the San Pedro River in the SDID and PWUA service areas. Outside of the irrigation district service areas well water is used exclusively to potentially irrigate about 3,300 acres. Table D-1 shows the acreage of agricultural and non-agricultural irrigation and the water sources in the Benson sub-area.

Table D-1. Agricultural and Non-Agricultural Potential Irrigation**.**
(All acres were not irrigated in May, 2002)

	BENSON SUB-AREA Surface and Well Water (acres)	**ST. DAVID IRRIGATION DISTRICT Surface and Well Water (acres)**	**POMERENE WATER USERS ASSOCIATION Surface and Well Water (acres)**	**NON – DISTRICT Well Water (acres)**
Agriculture	5,675	1,119	1,285	3,271
Non-Agriculture	32	3	0	29
TOTAL	**5,707**	**1,122**	**1,285**	**3,30**

ADWR observed and recorded the crop type, irrigation system type, field conditions and determined the irrigated acres. The crop survey allowed ADWR to classify irrigated acreages as "active irrigation" and "not actively irrigated." Irrigation use was determined by the presence or absence of a crop and conveyance system, and by the apparent condition of the crop, conveyance system and field. An irrigated field was identified as acreage that had an actively irrigated crop and the conveyance system and field appeared to be maintained for continued irrigation use. Fallow fields were identified as acreage that did not have an actively irrigated crop, but the conveyance system and field appeared

to be maintained for future irrigation use. Fields that were not irrigated were identified as acreage that did not have an actively irrigated crop, the conveyance system and field was not maintained or poorly maintained, and future use was uncertain. ADWR observed and mapped approximately 5,707 agricultural and non-agricultural acres and determined that 2,151 acres were irrigated, 420 acres were fallow, and 3,135 were not irrigated.

Table D-2 shows the agricultural and non-agricultural irrigation classifications and water sources in the Benson sub-area.

Table D-2. Agricultural and Non-Agricultural Irrigation Classifications.

	BENSON SUB-AREA Surface and Well Water (acres)	**ST. DAVID IRRIGATION DISTRICT Surface and Well Water (acres)**	**POMERENE WATER USERS ASSOCIATION Surface and Well Water (acres)**	**NON – DISTRICT Well Water (acres)**
AGRICULTURAL IRRIGATION				
Irrigation	2,120 (37%)	417	427	1,277
No Irrigation	3,135 (55%)	640	673	1,822
Fallow	420 (7%)	62	186	172
TOTAL	**5,675 (100%)**	**1,119**	**1,286**	**3,271**
NON-AGRICULTURAL IRRIGATION				
Irrigation	31	3		29
No Irrigation				
Fallow				
TOTAL	**31**	**3**		**29**

Table D-2 shows that ADWR observed about 2,120 acres of agricultural irrigation and only 31 acres of non-agricultural irrigation. Since the non-agricultural portion is relatively small, this report hereon will combine agricultural and non-agricultural irrigation acreage and describe and summarize it simply as irrigation acreage.

ADWR identified the non-deficit and deficit irrigation practices on actively irrigated acreage. Investigators observed and compared similar fields with the same crop type. A sufficiently irrigated crop generally exhibited healthy dense growth, green vegetation, uniform and even cover. A deficit-irrigated crop generally appeared stressed and sparse, short or stunted, thin, pale or brown, non-uniform or uneven throughout the field. Table

D-3 lists the plant and soil characteristics that were observed to determine normal and deficit irrigation.

Table D-3. Plant and Soil Characteristics of Normal and Deficit Irrigation Practices.

CHARACTERISTICS	NORMAL IRRIGATION	DEFICIT IRRIGATION
APPEARANCE	Healthy, turgid, erect, green to pale green	Stressed, wilted, limp, pale green to brown
GROWTH	Dense, uniform height and thickness	Thin, stunted, non-uniform height and thickness
COVER	Uniform density, evenly distributed, few bare spots	Non-uniform density, sparse, patchy or uneven, many bare spots.
SOIL	Irrigated, wet or moist	Not irrigated, dry, cracked, dusty

The irrigation status, described in terms of normal and deficit irrigation, is shown in Table D-4. These terms correspond to a level of irrigation and the associated crop and soil characteristics described in Table D-3. ADWR determined there were approximately 1,689 non-deficit irrigation acres and 462 deficit irrigation acres in the Benson sub-area. Table D-4 describes the irrigation status and acreage of all areas in the sub-area.

Table D-4. Irrigation Status.

STATUS	BENSON SUB-AREA	ST. DAVID IRRIGATION DISTRICT (acres)	POMERENE WATER USERS ASSOCIATION (acres)	NON – DISTRICT (acres)
Non-deficit irrigation	1,689 (79%)	210	395	1,085
Deficit Irrigation	461 (21%)	210	32	221
TOTAL	**2,150 (100%)**	**420**	**427**	**1,306**

The main types of irrigation observed in the Benson sub-area were flood (without tailwater pumpback systems) and sprinkler systems. A drip system was used in one location. Flood irrigation methods included basin, border, furrow and wildflood methods. Sprinkler systems included side-roll, center pivot and solid set. Table D-5 describes the irrigation systems and associated acreage in the Benson sub-area.

Table D-5. Irrigation Systems.

SYSTEMS	BENSON SUB-AREA (acres)	ST. DAVID IRRIGATION DISTRICT (acres)	POMERENE WATER USERS ASSOCIATION (acres)	NON – DISTRICT (acres)
Drip	4	4	0.0	0.0
Flood (w/o pumpback)	997	388	330	281
Sprinkler	1149	28	97	1024
TOTAL	**2150**	**420**	**427**	**1305**

ADWR observed about 997 acres that were flood irrigated, 1,149 acres irrigated by sprinklers, and just 4 acres irrigated by a drip system for a total of approximately 2,151 acres of active irrigation. The dominant crop was pasture with about 1, 993 irrigated acres. The remaining acreage included approximately 127 acres of grass, fruit trees, pasture and pecans, pine trees and vegetables, and 31 acres of non-agricultural crops including turf, landscape and fruit trees associated with domestic use. Table D-6 is a summary of the irrigated crops and acreage in the Benson sub-area.

Table D-6. Irrigated Crops**.**

CROPS	BENSON SUB-AREA (acres)	ST. DAVID IRRIGATION DISTRICT (acres)	POMERENE WATER USERS ASSOCIATION (acres)	NON – DISTRICT (acres)
Fruit Trees	8			8
Grass	7	7	0	0
Landscape	6	0	0	6
Pasture	1,993	334	427	1,233
Pasture & Pecans	48	48	0	0
Pecan Trees	36	27	0	10
Pine Trees	28	0	0	28
Turf	24	3	0	21
Vegetables	2	2	0	0
TOTAL	**2,152**	**421**	**427**	**1,306**

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APPENDIX E

APPENDIX E

Groundwater Use Estimates for Riparian Inventory of the Benson Sub-area

(Includes the area north of SPRNCA, inside the Roeske and Werrell (1973) Qal, and excludes irrigated areas from ADWR HSR)

Estimates of riparian groundwater use were derived from combining aerial photo analysis (Arizona Regional Image Archive (ARIA), 2004; U.S. Fish and Wildlife Service, 2002) with data from recently completed studies (Scott and others, 2004, in preparation; Dahm and others, 2002).

Riparian classifications and delineations were obtained from the National Wetlands Inventory, San Pedro River Wetland/Riparian Project, with digital orthophoto quadrangles dated December, 2001 (U.S. Fish and Wildlife Service, 2002). The class is defined by the tallest vegetation, making up at least 30% cover (U.S. Fish and Wildlife Service, 2002). No more than two dominance types are included in mixed classes, each with at least 30% cover (U.S. Fish and Wildlife Service, 2002). Flights to obtain aerial photography originally scheduled for early Fall, 2001 were delayed until December, 2001 due to weather. Some ground-truthing was conducted with good comparison to photointerpretation (David Dall, Regional Wetlands Coordinator, USFWS, personal commun., May, 2004).

Riparian community types and acreage estimates delineated initially by the National Wetlands Inventory were compared with May, 1996 imagery obtained from ARIA (2004) to obtain average densities of percent canopy cover. These data were then combined with community type use rates adapted from Scott and others (2004, in preparation) and Dahm and others (2002) to estimate riparian groundwater use (Table E-1).

The two mesquite vegetative categories (forested and scrub/shrub mesquite) comprising the majority of the riparian acreage in the Benson sub-area were assessed in greater detail for the St. David, Benson, and Galleta Fat East quadrangles. The other two quads, Land and Wildhorse Mountain (at far south and north end, respectively), contained minimal acreage which could be assessed readily. These two mesquite classifications identified by the National Wetlands Inventory were compared with the ARIA imagery to obtain an estimate of canopy cover density for each polygon delineated. Following the tabulation of acreages and corresponding canopy cover ranging in density from 30 – 90 percent, consumptive use estimates were totaled for each mesquite vegetative class (Table E-2).

The following summarizes the methodology used and assumptions made in estimating riparian groundwater use.

1. Consumptive use estimates for salt cedar were adapted from Dahm and others (2002). Consumptive use estimates for all other vegetative classes were adapted from Scott and others (2004, in preparation).

2. Dahm and others (2002) measured an average growing season evapotranspiration (ET) of a moderately-dense stand of salt cedar at 750 mm/yr. This non-flooding Sevilleta site along the Rio Grande is a few hundred meters away from the river with a depth to water of 2 m. Salt cedar is able to survive in water poor conditions; but are stressed when depth to water exceeds 4 m below land surface. For a moderately dense, monotypic stand where depth to water was greater than 4 m, ET was greatly reduced to half the transpiration rate found in a similar stand where depth to water was 2-3 m below land surface (Cliff Dahm, University of New Mexico, personal commun., May, 2004).

   Salt cedar consumptive use along the intermittent reach of the San Pedro River where depth to water is greater than 13 ft (4 m) is estimated at 375 mm/yr. In the younger alluvium adjacent to the San Pedro River in the Benson sub-area, the depth to water ranges from 10-50 feet below land surface (Arizona Department of Water Resources, 2002b). Most of the vegetation delineated as salt cedar is in an area where depth to water exceeds 13 ft (4 m); therefore, the consumptive use at the Sevilleta site (Dahm and others, 2002) was halved to account for the greater depth to water along the intermittent reach of the San Pedro River.

3. Consumptive use estimates for cottonwood and mesquite along the San Pedro River in the Benson sub-area are from estimates reported by Scott and others (2004, in preparation) from their work conducted in the SPRNCA. The estimated total groundwater use for cottonwood/willow along an intermittent reach was 410 mm and along a perennial reach was 970 mm in 2003 (Scott and others, 2004, in preparation, Table 4-1). The estimated total groundwater use for mesquite (average of measurements from 2001, 2002, and 2003) was 464 mm at 74% aerial coverage (Scott and others, 2004, in preparation; Table 3-1).

4. The "mixed deciduous/evergreen" classification was assumed to be similar to mixed deciduous, since the evergreen species listed on the U.S. Fish and Wildlife Service National Wetlands Inventory classification system (juniper, white spruce, emory oak, and blue spruce) are not likely to occur at the riverbed elevation of the San Pedro River.

5. The "forested mixed deciduous" classification was assumed to have an average canopy cover of 80% density (ARIA, 2004). This classification was assigned a vegetative mix of 30% mesquite, 30% salt cedar, and 20% cottonwood/willow with a total groundwater use of 446 mm/yr.

6. The "scrub/shrub mixed deciduous" classification was assumed to have an average canopy cover of 60% density (ARIA, 2004). This classification was

assigned a vegetative mix of 25% mesquite, 25% salt cedar, and 10% cottonwood/willow with a total groundwater use of 335 mm/yr.

7. The "mesquite/salt cedar" classification was assumed to have an average canopy cover of 70% density (ARIA, 2004). This classification was assigned a mix of 50% mesquite and 20% salt cedar with a total groundwater use of 410 mm/yr.

8. The "salt cedar/mesquite" classification was assigned a mix of 50% salt cedar and 20% mesquite with a total groundwater use of 374 mm/yr.

9. The "forested broad-leaf" classification was given the same consumptive use rate as cottonwood with a total groundwater use of 410 mm/yr.

10. The "needle-leafed deciduous" classification was given the same consumptive use rate as salt cedar with a total groundwater use of 375 mm/yr.

Table E-1. Groundwater Use Estimates for Riparian Inventory of the Benson Sub-area.

(Includes the area north of SPRNCA, inside the Roeske and Werrell (1973) Qal, and excludes irrigated areas from ADWR HSR)

Land Quadrangle

Attributes	Description	Acres	Consumptive Use Rate (mm/yr)	Consumptive Use Rate (in/yr)	Total Consumptive Use (in/yr)	Total Consumptive Use (ac-ft/yr)
RP1FO6CW	Forested Cottonwood	10.20	410	16.14	164.63	13.72
RP1FO8MD	Forest Mixed Decid/Evergreen	8.42	446	17.56	147.86	12.32
RP1SS6MQ	Scrub/Shrub Mesquite	86.00	310	12.21	1,050.06	87.51
RP1226SC	Scrub/Shrub Salt Cedar	17.27	375	14.76	254.91	21.24
					Quad Total CU (ac-ft/yr)	134.79

St. David Quadrangle

Attributes	Description	Acres	Consumptive Use Rate (mm/yr)	Consumptive Use Rate (in/yr)	Total Consumptive Use (in/yr)	Total Consumptive Use (ac-ft/yr)
RP1FO6CW	Forested Cottonwood	38.39	410	16.14	619.61	51.63
RP1FO6MD	Forested Mixed Decid	55.74	446	17.56	978.79	81.57
RP1FO6MQ	Forested Mesquite	94.48	464	18.27	1,726.15	143.85
RP1SS6MD	Scrub/Shrub Mixed Decid	66.83	335	13.19	881.49	73.46
RP1SS6MQ	Scrub/Shrub Mesquite	388.00	*	*	*	453.41
RP1SS6MQ/SC	Scr/Shr Mesq/Salt Cedar	12.17	410	16.14	196.42	16.37
RP1SS6SC	Scrub/Shrub Salt Cedar	65.60	375	14.76	968.26	80.69
RP1SS6SC/MQ	Scr/Shr Salt Cedar/Mesquite	98.78	374	14.72	1,454.04	121.17
					Quad Total CU (ac-ft/yr)	1,022.14

Benson Quadrangle

Attributes	Description	Acres	Consumptive Use Rate (mm/yr)	Consumptive Use Rate (in/yr)	Total Consumptive Use (in/yr)	Total Consumptive Use (ac-ft/yr)
RP1FO6CW	Forested Cottonwood	3.30	410	16.14	53.26	4.44
RP1FO6MD	Forested Mixed Decid	374.79	446	17.56	6,581.31	548.44
RP1FO6MQ	Forested Mesquite	0.02	464	18.27	0.37	0.03
RP1SS6MD	Scrub/Shrub Mixed Decid	27.36	335	13.19	360.88	30.07
RP1SS6MQ	Scrub/Shrub Mesquite	1,088.30	*	*	*	1,347.46
RP1SS6MQ/SC	Scr/Shr Mesq/Salt Cedar	14.64	410	16.14	236.29	19.69
RP1SS6SC	Scrub/Shrub Salt Cedar	237.62	375	14.76	3,507.27	292.27
					Quad Total CU (ac-ft/yr)	2,242.41

Galleta Flat East Quadrangle

Attributes	Description	Acres	Consumptive Use Rate (mm/yr)	Consumptive Use Rate (in/yr)	Total Consumptive Use (in/yr)	Total Consumptive Use (ac-ft/yr)
PF01Ch	Forested Broad-Leaf	13.17	410	16.14	212.56	17.71
RP1FO6CW	Forested Cottonwood	5.21	410	16.14	84.09	7.01
RP1FO6MQ	Forested Mesquite	622.90	*	*	*	961.13
RP1FO8MD	Forest Mixed Decid/Ever	5.00	446	17.56	87.80	7.32
RP1SS6CW	Scrub/Shrub Cottonwood	0.07	410	16.14	1.13	0.09
RP1SS6MQ	Scrub/Shrub Mesquite	996.50	*	*	*	1,204.95
RP1SS6SC	Scr/Shr Salt Cedar	273.62	375	14.76	4,038.63	336.55
RP1SS8MD	Sc/Sh Mixed Decid Evergr	161.51	335	13.19	2,130.32	177.53
					Quad Total CU (ac-ft/yr)	2,717.05

Wildhorse Mountain Quadrangle

Attributes	Description	Acres	Consumptive Use Rate (mm/yr)	Consumptive Use Rate (in/yr)	Total Consumptive Use (in/yr)	Total Consumptive Use (ac-ft/yr)
RP1FO6MQ	Forested Mesquite	23.77	464	18.27	434.28	36.19
RP1SS6MQ	Scrub/Shrub Mesquite	1.33	310	12.21	16.24	1.35
					Quad Total CU (ac-ft/yr)	37.54
					TOTAL ALL QUADS	6,153.93

Notes:

*Refer to Table E-2 for consumptive use estimates of mesquite vegetative classifications from St. David, Benson and Galleta Flat East quadrangles.

Wetland/riparian classifications and delineations obtained from U.S. Fish & Wildlife Service, 2002, National Wetlands Inventory, San Pedro River Wetland/Riparian Project; photography - December, 2001; ADWR GIS map files \\adwrnetra\userlib\wrmrp\hydro\basins\uppersanpedro\projects\frankputman\spedrowetlandriprianinventory.

Two wetland emergent classifications totaling about 20 acres were not included in this analysis.

Depth to water in wells located in floodplain alluvium ranges from 10 - 50 feet below land surface; difference between water level elevation in wells and riverbed elevation ranges from 1 - 15 feet (Arizona Department of Water Resources, 2002b).

Consumptive use estimates adapted from Cliff Dahm (Department of Biology, University of New Mexico, personal commun., May, 2004), Scott and others (2004, in preparation), and Dahm and others (2002).

Table E-2. Groundwater Use Estimates for Mesquite Vegetative Classifications of the Benson Sub-area.

(Includes the area north of SPRNCA, inside the Roeske and Werrell (1973) Qal, and excludes irrigated areas from ADWR HSR)

St. David Quadrangle

Attributes	Acres	% Canopy Cover	Consumptive Use Rate (mm/yr)	Consumptive Use Rate (in/yr)	Total Consumptive Use (in/yr)	Total Consumptive Use (ac-ft/yr)
RP1SS6MQ	194	50	310	12.20	2,367.72	197.31
Scrub/Shrub	99	60	372	14.65	1,449.92	120.83
Mesquite	95	70	434	17.09	1,623.23	135.27
	388				Total CU (ac-ft/yr)	453.41

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Benson Quadrangle

Attributes	Acres	% Canopy Cover	Consumptive Use Rate (mm/yr)	Consumptive Use Rate (in/yr)	Total Consumptive Use (in/yr)	Total Consumptive Use (ac-ft/yr)
RP1SS6MQ	23.3	70	434	17.09	398.12	33.18
Scrub/Shrub	15.8	50	310	12.20	192.83	16.07
Mesquite	44.2	40	248	9.76	431.56	35.96
	152.8	50	310	12.20	1,864.88	155.41
	60.7	70	434	17.09	1,037.16	86.43
	37.7	30	186	7.32	276.07	23.01
	181	80	496	19.53	3,534.49	294.54
	8.1	70	434	17.09	138.40	11.53
	3.7	60	372	14.65	54.19	4.52
	2.7	60	372	14.65	39.54	3.30
	13.9	70	434	17.09	237.50	19.79
	62.4	40	248	9.76	609.26	50.77
	181	80	496	19.53	3,534.49	294.54
	8.1	70	434	17.09	138.40	11.53
	3.7	60	372	14.65	54.19	4.52
	2.7	60	372	14.65	39.54	3.30
	13.9	70	434	17.09	237.50	19.79
	62.4	40	248	9.76	609.26	50.77
	181	80	496	19.53	3,534.49	294.54
	8.1	70	434	17.09	138.40	11.53
	3.7	60	372	14.65	54.19	4.52
	2.7	60	372	14.65	39.54	3.30
	13.9	70	434	17.09	237.50	19.79
	62.4	40	248	9.76	609.26	50.77
	44.4	70	434	17.09	758.65	63.22
	198.9	60	372	14.65	2,913.02	242.75
	49.1	70	434	17.09	838.95	69.91
	16.4	70	434	17.09	280.22	23.35
	11.5	70	434	17.09	196.50	16.37
	161.7	60	372	14.65	2,368.20	197.35
	2.7	60	372	14.65	39.54	3.30
	13.9	70	434	17.09	237.50	19.79
	62.4	40	248	9.76	609.26	50.77
	44.4	70	434	17.09	758.65	63.22
	198.9	60	372	14.65	2,913.02	242.75
	49.1	70	434	17.09	838.95	69.91
	16.4	70	434	17.09	280.22	23.35
	11.5	70	434	17.09	196.50	16.37
	161.7	60	372	14.65	2,368.20	197.35
	1088.3				Total CU (ac-ft/yr)	1,347.46

Galleta Flat East Quadrangle

Attributes	Acres	% Canopy Cover	Consumptive Use Rate (mm/yr)	Consumptive Use Rate (in/yr)	Total Consumptive Use (in/yr)	Total Consumptive Use (ac-ft/yr)
RP1F06MQ	135.6	80	496	19.53	2,647.94	220.66
Forested	271.3	80	496	19.53	5,297.83	441.49
Mesquite	107.9	75	465	18.31	1,975.33	164.61
	102.1	60	372	14.65	1,495.32	124.61
	6	80	496	19.53	117.17	9.76
	622.9				Total CU (ac-ft/yr)	961.13

	Acres	% Canopy Cover	Consumptive Use Rate (mm/yr)	Consumptive Use Rate (in/yr)	Total Consumptive Use (in/yr)	Total Consumptive Use (ac-ft/yr)
RP1SS6MQ	28.3	80	496	19.53	552.63	46.05
Scrub/Shrub	9	80	496	19.53	175.75	14.65
Mesquite	70.6	80	496	19.53	1,378.65	114.89
	11.4	80	496	19.53	222.61	18.55
	9.6	90	558	21.97	210.90	17.57
	41.9	70	434	17.09	715.93	59.66
	9.6	40	248	9.76	93.73	7.81
	9.5	40	248	9.76	92.76	7.73
	15.2	40	248	9.76	148.41	12.37
	6	70	434	17.09	102.52	8.54
	60.3	60	372	14.65	883.13	73.59
	57.9	70	434	17.09	989.31	82.44
	105.6	50	310	12.20	1,288.82	107.40
	94.4	40	248	9.76	921.70	76.81
	66.6	60	372	14.65	975.40	81.28
	270.4	60	372	14.65	3,960.19	330.02
	23.4	50	310	12.20	285.59	23.80
	11.2	30	186	7.32	82.02	6.83
	11.4	40	248	9.76	111.31	9.28
	33.5	70	434	17.09	572.40	47.70
	36.1	50	310	12.20	440.59	36.72
	4.1	50	310	12.20	50.04	4.17
	10.5	80	496	19.53	205.04	17.09
	996.5				Total CU (ac-ft/yr)	1,204.95

Notes:
Percent canopy cover estimated from May 1996 imagery obtained from Arizona Regional Image Archive (2004).

Digital orthophoto quarter quads (DOQQ) utilized included St. David SW; Benson NE, SE; Galleta Flat East - NE, NW, SE (Arizona Regional Image Archive, 2004).

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APPENDIX F

APPENDIX F

Municipal & Industrial Incidental Recharge (IR) - USP Basin

Municipal Incidental Recharge	1985	1990	2002	2010	2020	2030
Benson sub-area						
Benson non-sewered provider population	1,658	1,922	4,058	4,161	4,589	4,760
Benson non-sewered provider IR	128	149	314	322	355	368
Benson exempt well population	1,818	2,087	3,227	4,131	4,672	4,979
Benson exempt well IR	141	161	249	319	361	385
San Pedro Golf Course + other water demand			500	717	988	1,194
San Pedro Golf Course IR			25	36	49	60
Bachmann Springs Golf Course water demand				500	500	500
Bachmann Springs Golf Course IR				25	25	25
Benson sub-area total municipal IR	**269**	**310**	**588**	**677**	**790**	**837**
Sierra Vista sub-area						
Sierra Vista non-sewered provider and exempt well population	15,597	17,080	24,070	25,657	27,889	29,931
Sierra Vista non-sewered provider and exempt well IR	1,205	1,320	1,860	1,983	2,156	2,313
City of Tombstone population	1,426	1,220	1,535	1,595	1,611	1,655
City of Tombstone IR	99	85	107	111	112	115
Mountain View G.C. & Chaffee Parade Grounds water demand	340	340	424	370	370	370
Mountain View Golf Course + Chaffee Parade Grounds IR	17	17	21	19	19	19
Veterans Park water demand	184	184	179	179	179	179
Veterans Park IR	9	9	9	9	9	9
Sierra Vista sub-area total municipal IR	**1,331**	**1,431**	**1,997**	**2,121**	**2,295**	**2,456**
Total Basin Municipal Incidental Recharge	**1,600**	**1,741**	**2,585**	**2,798**	**3,085**	**3,293**

* Interior use results in septic tank recharge. Assumes interior use is consistent Basin-wide and is 69 GPCD based on AWWA 1999 Residential End Use Study
* Assumes 100% of interior use is recharged (Verde River Watershed Study, ADWR 2000a)
* Assumes 95% of the Sierra Vista incorporated area is sewered (ADWR, 1991a)
* Assumes 100% of the Benson incorporated area is sewered
* Tombstone IR; effluent is discharged to Walnut Gulch. Assumes 90% of the effluent is recharged (ADWR 1999b, pg.11-15)
* Approximately 1,190 of the Bisbee population is non-sewered with plans to sewer 950. Assumed half will be sewered by 2010 and remainder by 2020.
* Because DES population projections are used and new Bisbee connections occur after 2002, IR estimates plateau after 2002 (assumes some existing population may become incorporated but remain unsewered)
* The incidental recharge factor for turf-related facilties is from the SCAMA TMP (ADWR, 1999a) industrial incidental recharge factor (primarily turf-related) of 5% of use

Industrial Incidental Recharge	1985	1990	2002	2010	2020	2030
Benson sub-area						
Turquoise Hills Golf Course water demand	127	127	500	500	500	500
Benson sub-area total industrial IR	**6**	**6**	**25**	**25**	**25**	**25**
Sierra Vista sub-area						
Turquoise Valley Golf Course water demand	500	500	575	575	575	575
Pueblo del Sol Golf Course water demand	500	500	500	500	500	500
Additional Sierra Vista golf course water demand					500	500
Sierra Vista sub-area total industrial demand	1000	1000	1075	1075	1575	1575
Sierra Vista sub-area total industrial IR	**50**	**50**	**54**	**54**	**79**	**79**
Total Basin Industrial Incidental Recharge	**56**	**56**	**79**	**79**	**104**	**104**

* Incidental recharge factor for turf-related facilties is from the SCAMA TMP (ADWR, 1999a) industrial incidental recharge factor (primarily turf-related) of 5% of use

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APPENDIX G

APPENDIX G

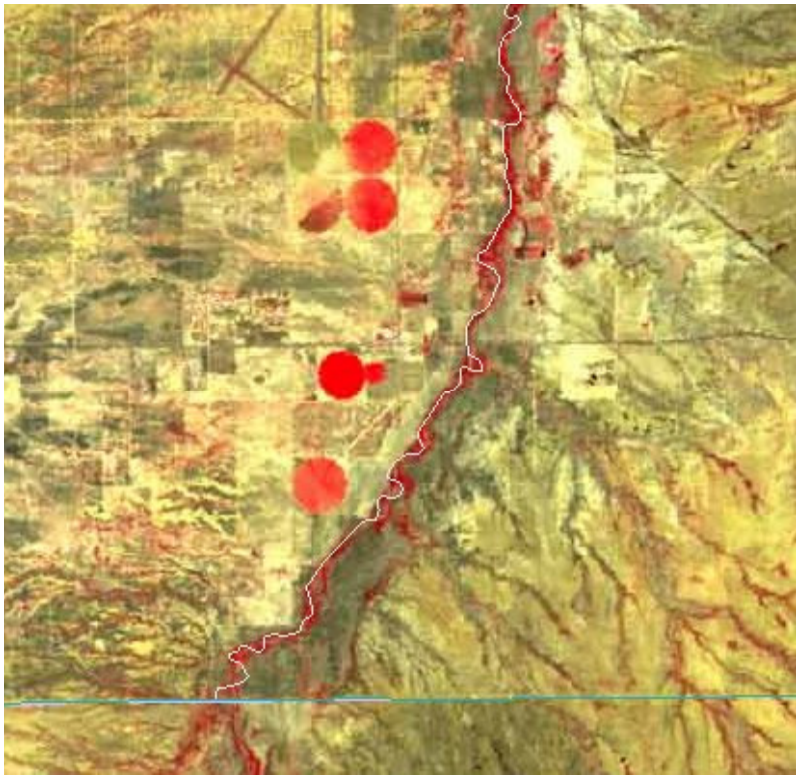
Agricultural Acreage and Water Demand Assumptions

Primary Information Sources

1. Infra-red satellite images from April 1984, May 1990, July 1997 and May 2001.
2. Arizona Department of Water Resources, 1991a,b, Hydrographic Survey Report for the San Pedro River Watershed. Volume 1: General Assessment and Volume 3: Sierra Vista Subwatershed Watershed File Reports. (San Pedro HSR).
3. May 2002 field survey by ADWR staff in the Benson sub-area.
4. January, February and July 2003 fieldwork by ADWR staff in the Sierra Vista sub-area.
5. U.S. Army, 2000, Fort Huachuca ESA Compliance Aerial Photo Analysis of the San Pedro and Babocomari Rivers.
6. Arizona Department of Water Resources, 1999a, Santa Cruz AMA Third Management Plan, 2000-2010.
7. Saint David Irrigation District 2001 diversion data.

Historic and Current Acreage Determination

Infra-red satellite images of the entire Basin were examined for evidence of irrigation for historic years (1985 and 2000) except as noted below. Non-deficit irrigation occurs on the images as bright red. Deficit irrigation is not clearly discernible from satellite images. Deficit irrigated (DI) crops are irrigated with less water than non-deficit irrigated crops which are irrigated with sufficient water to meet the consumptive use (CU) requirement of the crop grown. The CU is the amount of water used in transpiration and building of plant tissue, together with the amount of water evaporated from adjacent soil during the growing season. It is also sometimes difficult to distinguish the non-deficit irrigated acres from satellite images, especially those in close proximity to riparian vegetation. In addition, fields no longer irrigated may appear to be irrigated on satellite images after substantial amounts of rainfall.



The satellite image at left shows clearly the center pivot irrigated fields in July 1997 in the Upper San Pedro Basin near the border with Mexico. The large circles are approximately ½ mile in diameter. By 2002, the two large and one small

southerly center-pivot irrigated fields were out of production and the 2½ large center pivot irrigated fields had expanded to four large center pivot irrigated fields. This image shows the difficulty of distinguishing deficit-irrigated acres from riparian and other vegetation and the need for field verification.

To estimate the number of deficit and non-deficit irrigated acres in 1985 for the Sierra Vista and Benson sub-areas, and in 1990 for the Benson sub-area, the proportion of deficit irrigated acreage to active irrigated acreage information in the San Pedro HSR was used. This deficit irrigated percentage was 15% for the Benson sub-area and 60% for the Sierra Vista sub-area for fields greater than 2 acres in size. For 2002, field verification was conducted to supplement the satellite images and to determine the number of deficit and non-deficit irrigated acres. The sum of the deficit irrigated acres and non-deficit irrigated acres equals the total irrigated acres for the sub-area.

Satellite imagery analysis was not used for the Sierra Vista sub-area in 1990 because the images showed extremely few acres under active irrigation, perhaps due to a postponement of irrigation or some other reason. Therefore, the number of irrigated acres from the San Pedro HSR were used. The table references below refer to tables in the San Pedro HSR. Shown below are the number of deficit and non-deficit acres estimated in the San Pedro HSR and the derivation of acreage less than 2 acres in size, which are included in the municipal demand category:

Sierra Vista sub-area:

Estimate based on: 1007.4 aces of AAI (Table C-17)
+601.8 acres of deficit irrigation (Table C-16)
- 235.5 acres of vineyards outside groundwater basin (Table C-14)
= 1373.7 acres > 2 acres in size

Irrigated acres < 2 acres based on: 2,597.7 ac. total active PWR acres (Table C-15)
- 1,007.4 ac. AAI (Table C-17)
- 416.5 ac. not irrigated (Table C-15)
- 601.8 ac. deficit irrigation (Table C-16/C-15)
= 572 ac. < 2 acres in size

Note: assumes all < 2 ac. from HSR is within the groundwater basin.
AAI =average acres irrigated (non-deficit); PWR = potential water right

The San Pedro HSR identified 235.5 acres of vineyards in the Sierra Vista sub-watershed in 1990. The vineyards were not identifiable on the satellite images. Upon review of the San Pedro HSR files it was determined that all but 20 acres of these vineyards are outside of the Basin boundary.

Sierra Vista sub-area satellite imagery for 2001 was supplemented with a 2003 field survey of agricultural lands (described in Appendix H), aerial photo analysis (Fort Huachuca ESA Compliance Aerial Photo analysis of the San Pedro and Babocomari Rivers), and review of the San Pedro HSR watershed file report information.

Benson sub-area agricultural acreage in 2002 was determined from a field survey (described in Appendix D). However, because access was restricted in some areas, the field data was supplemented with satellite data to determine the total number of irrigated acres. This resulted in an additional 217 acres of active irrigated land added to the field survey data and a recalculation

of the deficit irrigated acres using the proportional method described above after addition of these acres.

Prior to 2002, effluent from the Benson and Sierra Vista Waste Water Treatment Plants (WWTP) was surface discharged to pasture; 313 acres at Sierra Vista and 22 acres at Benson. Bisbee effluent discharge to land is minimal and was not included in agricultural estimates. Beginning in 2002, 313 effluent irrigated acres at the Sierra Vista WWTP identified in the 2001 satellite image were subtracted from the active irrigated acres. The effluent is currently recharged in an underground storage project. Beginning in 2002, 22 effluent irrigated acres of pasture at the Benson WWTP identified in the 2001 satellite image was subtracted from the active irrigated acres. The effluent is currently delivered for golf course irrigation. Both of these demands are accounted for under the municipal sector demand.

Projected Acreage

Since 1985 there has been a substantial reduction in the number of irrigated acres within the Basin due to establishment of the San Pedro Riparian National Conservation Area, development, purchase of irrigated land for conservation purposes, and economic conditions. It is likely that agricultural use will continue to decline although it is difficult to predict what the decline rate might be. For that reason it was assumed that agricultural acreage will remain constant through the projection period with the following exception. Beginning in 2010, 40 acres of vineyards at the Bachmann Springs development were added to the Benson sub-area budget as proposed in the Bachmann Springs master plan.

Agricultural Demand

Agricultural demand was estimated by multiplying the number of deficit and non-deficit irrigated acres by the appropriate CU value. As mentioned above, the Benson sub-area field survey of 2002 yielded data on the number of non-deficit and deficit irrigated acres. For the Sierra Vista sub-area, it was assumed that the four center pivot irrigated fields were non-deficit irrigated and that all other irrigated acreage was deficit irrigated.

For 2002, a weighted average CU was calculated for each sub-area by multiplying the CU value of each crop by the number of crop acres and then dividing the resulting total demand by the total number of acres. For the Benson sub-area, it was possible to calculate the average CU based on the 2002 field survey. For the Sierra Vista sub-area, the CU for alfalfa was used to calculate the demand of the four center pivot irrigated acres. For the "other" acreage, an average CU was calculated by assuming that the same crop mix existed in 2002 as that present at the time of the San Pedro HSR investigations (excluding 235.5 acres of vineyards outside the Basin boundary). Pasture is the predominant crop irrigated in the Basin.

CU values from the Santa Cruz AMA (SCAMA) Third Management Plan, Appendix 4 were used due to its similarity to conditions in the USP Basin. These values are approximate and are not identical to those in the San Pedro HSR, which were derived based on local weather and cropping practices at the time of that investigation and which could not be duplicated for this review. The weighted average CU using the SCAMA CU values are somewhat higher than those in the San Pedro HSR (by about ½ acre-foot/acre). In the Benson sub-area the weighted average CU calculated from the 2002 field data is 3.43 acre-foot/acre. For the Sierra Vista sub-area the weighted average CU is 3.04 acre-foot/acre for the "other" acres, and the CU of the center pivot irrigated acres is 3.43 (based on an estimated crop yield of 5.5 tons per acre). The CU for grapes in the SCAMA Third Management Plan is 3.0 acre-foot/acre.

To estimate the demand of deficit irrigated acres, the CU was multiplied by a factor of .86 to reflect that these cropped acres were using less than the crop CU. The factor of .86 was calculated using actual data on deficit irrigated Bermuda grass (pasture) in the Tucson AMA.

In summary, for 2002:

- Sierra Vista sub-area CU's:
  - CU for active irrigation acres (4 center-pivots) = 3.43 acre-feet/acre (af/ac) based on the CU for alfalfa
  - Vineyard CU = 3.0 af/ac.
  - Deficit irrigated demand = 3.04 af/ac x 0.86

- Benson sub-area CU's:
  - CU for active irrigation acres = 3.43 af/ac based on crop mix recorded from the May 2002 fieldwork.
  - Deficit irrigated demand = 3.43 af/ac x 0.86

- Sierra Vista sub-area 2002 demand:
  (503 acres x 3.43 af/ac.) + (280 DI acres x 3.04 af/ac. x .86) + (20 acres x 3.0 af/ac.) = 2,517 af

- Benson sub-area 2002 demand
  (1906 acres x 3.43 af/ac.) + (244 acres x 3.43 af/ac x .86) = 7,257 af

Agricultural Supply

Sierra Vista sub-area irrigation is assumed to be groundwater. There was no evidence of surface water diversions in the 2003 field surveys. All irrigation parcels have wells. Some acreage has surface water rights claims. The watershed file reports from the San Pedro HSR indicate that both surface water and groundwater could have been used on some parcels at that time, however it is not possible from these reports to distinguish between the surface water and groundwater use volumes.

Benson sub-area irrigation is a combination of surface water and groundwater. Surface water volume was determined from 2001 diversion data from the Saint David Irrigation District (SDID) and from San Pedro HSR records for Pomerene Water Users Association (PWUA).

- SDID:
  - 2,012 hrs. x 60 min. x 4,500 gpm (max.) / 325,851 gal/af = 1,667 af/yr surface water diverted.
  - Assumed 5.6% canal seepage and evaporation (Table 5-29, San Pedro HSR) and excess application of 26% (Table 5-18, San Pedro HSR; used value for PWUA).
    1,667 af x .944 x .74 = 1,165 af utilized

- PWUA:
  - 1,134 af/yr utilized (Table 5-16, San Pedro HSR; 1,563 af diverted, 37 af lost through evaporation and seepage and 392 af delivered in excess).

- Total surface water used: 1,165 af +1,134 af = 2,299 af

It was assumed that PWUA and SDID will divert as much surface water as available before pumping groundwater and that lacking any long-term and complete current records of surface water diversions, these estimates represent historic, current and projected surface water diversions. It was assumed that the remaining water demand (about 5,000 acre-feet), estimated by the acreage and CU method described previously, would be met by groundwater.

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APPENDIX H

APPENDIX H

Sierra Vista Sub-area Agricultural Lands Assessment

Infra-red satellite images were analyzed for the presence of current (2001/2002) active irrigation in the Sierra Vista sub-area. Using this method, four center pivots located in Sec. 29 Township 23 South, Range 22 East, were clearly identified. These areas were estimated to total 503 acres (four, .5 mile diameter circles), and later verified through a field visit and aerial photos. When viewing images, it is difficult to distinguish irrigated lands from riparian vegetation along the San Pedro River and not possible to identify deficit irrigated agricultural lands. Several methods were used to estimate the number of those irrigated acres. In most cases, more than one method was used to verify irrigation for each potentially irrigated parcel. These methods include the following:

1. Field investigation of lands with agricultural tax codes
2. Field investigation of agricultural lands identified in the San Pedro HSR in the Palominas (Gap) area.
3. Analysis of Fort Huachuca ESA compliance aerial photos of the San Pedro and Babocomari Rivers
4. Review of other agricultural lands identified in the San Pedro HSR, 1991.

1. Agricultural Tax Code Lands

Tax parcel information for agricultural lands in the Sierra Vista sub-area was received from Rick Koehler, EEC, December 4, 2002, as a potential alternative method to identify agricultural lands. This was in the form of a property status query of Arizona Department of Revenue file data by land use code. On January 10, 2003, ADWR staff visited most of these lands. This information was used in conjunction with other information to verify irrigation status.

1. T20S, R20E, Sec. 24; Part of this area straddles the Babocomari River. There is riparian vegetation including mesquite bosque. The upland area is grassland and mesquite. The area is primarily large lot residential. No agricultural fields or irrigation were observed.
2. T23S, R20E, Sec.23; Primarily National Forest Land surrounding privately held land. Private land, Beatty's Miller Canyon Guest Ranch, Apiary and Orchard, includes a 7-acre apple orchard (1300 trees according to website). Spoke with owner, Thomas Beatty Sr. regarding irrigation. Mature trees are not watered. Young trees are watered by hose or by bucket. Small spring-fed pond observed.
3. T23S, R22E, Sec. 17 and 20; Cattle observed but no irrigation. Large lot residential area. 40 acre parcel in SE1/4 had a center pivot in place but yucca on site and vegetation in tracks; no recent irrigation. New residential development adjacent west and north of parcel.
4. T23S, R22E, Sec. 15; Rancho del Rio. Approximately 20-acre pasture that had previously been sprinkler irrigated. No equipment observed. Small pond near road.
5. T23S, R22E, Sec. 27 and 34; Large lot development in section 27, some pasture lands in section 34, no irrigation system observed. (Section 34 lands are the Warne and Wiek properties described in section 2 below.)
6. T23S, R22E, Sec. 29; Four center pivots. Two east fields were tilled and ready for irrigation. Could not observe southwest pivot area condition but pivot in place.

2. Field Investigation of Agricultural Lands Identified in the San Pedro HSR in the Palominas (Gap) Area

Selected San Pedro HSR agricultural lands in the "gap" area were compared with current conditions. This site visit, initially done during a period of dormancy, February 2003, was supplemented with analysis of satellite images (May 2001) and photos (November 2000) to reasonably determine whether the lands were actually irrigated. Most of these lands were revisited during the active growing season, July 2003. Table H-1 summarizes the findings of the field visits. A description of the field conditions and photos (when available) of these HSR irrigated acres follows (with the exception of the Drijver property, which has a TNC conservation easement).

Table H-1. Field Investigated Lands in the Palominas (Gap) Area

HSR Land Owner	HSR Irrigated Acres	Current Irrigated Acres	Comments
Barnett	10	10	Aerial photo identification, 7/03 field visit; orchard
Barney	72.9	0	Purchased for development
Brock (Arntz)	33	33	Additional photo verification
Dinwiddie	68.7	0	Additional aerial photo verification
Drijver	81.8	0	TNC conservation easement
Leftault (Rancho del Rio)	37.7	37.7	Aerial photo verification
Stoner	21.1	4	Field verification only
Warne	119.6	0	Additional aerial photo verification
Wiek	165.9	86	Additional aerial photo verification
Total	**600.7**	**170.7**	

Barnett Property; T23S, R22E, E½ of E½ Sec. 28 (7/03, no site photo available)

1) Source of water: well
2) Pecan orchard
3) Irrigation system: drip
4) Irrigation status: assumed active
5) Irrigation classification: active, trees appeared healthy

Barney Property; T23S, R22E, N ½ of SW ¼ Sec. 33

1) Source of water: well
2) Former pasture
3) Irrigation system: side roll
4) Irrigation status: not applicable
5) Irrigation classification: non-active, moderate to large shrubs observed in fields

Barney property; looking east from Palominas Road (2/03).

Brock (Arntz) Property T23S, R22E, Sec. 33

1) Source of water: well
2) Former pasture
3) Irrigation system: flood
4) Irrigation status: not applicable
5) Irrigation classification: active/fallow

Brock (Arntz) property; looking north from southwest corner of property (2/03).

Dinwiddie Property; T23S, R22E, Sec.27

1) Source of water: well
2) Former pasture
3) Irrigation system: no evidence
4) Irrigation status: not applicable
5) Irrigation classification: non-active, no evidence of any recent irrigation with moderate to large trees observed in fields

Dinwiddie property; looking southeast from the northwest property boundary, towards houses and wells, east of San Pedro River (2/03).

Dinwiddie property; depression for stockwatering? Grazing only sign of recent activity (2/03).

Dinwiddie property; looking south from north part of property (2/03).

Leftault Property (Rancho del Rio); T23S, R22E, Sec. 15

1) Source of water: well
2) Pasture
3) Irrigation system: flood but no equipment visible
4) Irrigation status: not applicable
5) Irrigation classification: active. 38 acres

Leftault property (Rancho del Rio); looking west from Hereford Road (2/03)

Stoner Property. T23S, R22, E SE ¼ of SW ¼ Sec.21

1) Source of water: well
2) Former pasture
3) Irrigation system: side roll sprinkler
4) Irrigation status: not applicable
5) Irrigation classification: approximately 12.6 ac. non-active, some small shrubs in former pasture; approximately 4 ac. active/fallow. 4.5 acres not observed

Stoner property: south field looking northwest at side roll sprinklers (2/03).

Stoner property; looking west toward pressure tank and well (2/03).

Stoner property; north field, looking southwest, side roll sprinklers, no trees (2/03).

Stoner property; north half of north field, looking west, with an approximately 40-yard section freshly plowed (2/03).

Warne Property T23S, R22E, Sec. 34

1) Source of water: well
2) Former pasture
3) Irrigation system: flood; unconnected sections of pipe observed
4) Irrigation status: not applicable
5) Irrigation classification: non-active

Warne property; looking north from south boundary of property; small to moderate sized trees and shrubs (2/03).

Warne property; from dirt road east of property looking west near center of Property (2/03).

Wiek Property T23S, R22E, Sec. 34 (no site photo available)

1) Source of water: well
2) Pasture
3) Irrigation system: flood, sections of pipe observed
4) Irrigation status: not applicable
5) Irrigation classification: potentially partially active; approximately 20 acres of newly plowed land observed from road to the east; could not approach most of the property

3. Analysis of Fort Huachuca ESA compliance aerial photos of the San Pedro and Babocomari Rivers

Aerial photos of the SPRNCA and other areas along the San Pedro and Babocomari Rivers, at a scale of 1:6000, were loaned to ADWR for identification of agricultural lands. The photos were taken November 29, 2000. The photos, in conjunction with the satellite and field analysis, were used to verify potentially irrigated lands and to measure irrigated acres of some fields. The entire length of the Babocomari River and adjacent areas, from approximately the western boundary of the Upper San Pedro Basin to the confluence with the San Pedro River, and other areas photographed outside of the SPRNCA boundaries, were examined.

4. Review of other agricultural lands identified in the San Pedro HSR or observed.

The San Pedro HSR was reviewed for potential agricultural irrigation in the Sierra Vista sub-area, excluding areas now within the SPRNCA boundaries or within the "Gap" area (Table H-1). Areas were examined using aerial photos (A), satellite imagery (S) or field investigated (F); small acreages are not included. Some parcels could not be verified (NV). In these cases it was assumed that the HSR acres were currently irrigated. Listed below are the landowners identified in the HSR, location, watershed file report number, number of acres, irrigation status and identification code (A, S, F, NV as cited above). The acreages in bold are assumed to be currently irrigated. Also listed are parcels observed when conducting other investigations.

1. Buchanan/Schmidt; 20S, 18E, Sec. 3; 111-19-ACA001; 20.4 acres. (S/F) Inactive 7/03.
2. Babocomari Ranch; 21S, 19E, Sec. 5&6; 111-19-DAC001; **31.3** acres pasture (A/S); HSR notes surface water and well water used for irrigation but inconclusive information.
3. Stockton; 20S, 18E, Sec. 33; 111-19-019; HSR discontinued irrigation
4. Herrington; 20S, 20E, Sec. 27; 111-20-CAAB003; **8.5** acres (A)
5. Lindsey; 21S, 22E, Sec.6; 111-20-DAD001; **25.3** acres (A)
6. Stewart Title; 21S, 22E, Sec. 9&10; 111-21-024; HSR no irrigation noted
7. Bishop; 21S, 22E, Sec. 23; 111-21-CCA001; 35 acres, no current irrigation (S).
8. Levinson; 22S, 18E, Sec. 15; 111-22-ABC001; **26** acres pasture along Turkey Creek, current irrigation status inconclusive (S). HSR notes surface water diversion and well used for irrigation.
9. Fry; 23S, 20E, Sec. 3; 111-23-BDCA009; **4** acres of fruit trees along Ramsey Creek (NV)
10. Beatty; 23S, 20E, Sec.23; 111-23-CAA001; **7** acres of fruit trees (F).
11. Marshall; 23S, 21E, Sec.18; 111-23-DBB026; HSR discontinued irrigation (9 ac.)
12. Richards; 24S, 21E, Sec.17; 111-23-DCC001; 27.6 acres, no current irrigation (S).
13. Barker; 23S, 23E, Sec.8; 111-24-BDC008; **7** acres (NV)
14. Dunn; 23S, 22E, Sec.35; 111-24-CBD001; HSR discontinued irrigation
15. Mott (SLD?); 24S, 22E, Sec.3; 111-24-CCB002; No irrigation (A).
16. Stewart Title #3210; 24S, 24E, Sec.17; 111-24-DCD010; No irrigation (A)
17. Miller; 24S, 24E, Sec.16; 111-24-043; irrigation of less than 2 acres
18. Phelps Dodge; 24S, 24E, Sec.3,4,9; 111-24-DDB001; HSR discontinued irrigation (119 ac.)
19. Dutt; 21S, 18E, Sec.7 (from well data; no file report). **20** acres Sonoita Vineyards (NV; website)
20. South of Rancho del Rio is the San Pedro Inn, formerly irrigated pasture. Currently small ponds and landscape irrigation.
21. 1.5 miles west of Huachuca City and south of Babocomari River, site of former irrigation on the Lazy D-S Ranch.

From this review, there is the potential for a maximum of **129.1** irrigation acres. All acreages, except vineyards, were assumed to be deficit irrigated.

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APPENDIX I

APPENDIX I

USP Basin Population Estimates and Projections

SIERRA VISTA SUB-AREA

	1985	1990	2000	2002	2010	2020	2030
Bisbee city limits	6721	6288	6090	6140	6676	6692	6737
Fort Huachuca	10502	9210	8413	8413	8413	8413	8413
Huachuca city limits	1721	1782	1751	1800	2229	2362	2469
Sierra Vista city limits	18286	23381	29362	32002	37652	43483	47604
Tombstone city limits	1426	1220	1504	1535	1595	1611	1655
Total incorporated population served	**38656**	**41881**	**47120**	**49890**	**56565**	**62561**	**66878**
Water provider connections outside city limits			3980				
Estimated unincorporated population served	**8688**	**8382**	**10428**	**10054**			
Total population served	**47344**	**50263**	**57548**	**58913**	**63487**	**69700**	**74421**
Exempt wells	1018	1343	2238	2378	2755	3267	3656
Persons per exempt well	4.72	4.72	4.72	4.72	4.72	4.72	4.72
Estimated exempt well population	**4805**	**6339**	**10574**	**11226**	**13005**	**15421**	**17257**
Sierra Vista Sub-area Population	**52149**	**56602**	**68122**	**70139**	**76491**	**85121**	**91677**

* Entire Bisbee population included.
* Projections assume 72% of future population is served by a water provider (based on 2000 percentage); this forces the unincorporated population served down. Remainder is exempt well population.
* Historic exempt well population based on number of wells and 2000 person per well
* Projected exempt well population is the sub-area population minus Fort Huachuca and water provider population.

BENSON SUB-AREA

	1985	1990	2000	2002	2010	2020	2030
Benson city limits	3737	3824	4711	4894	7650	9572	11050
Total incorporated population served	**3737**	**3824**	**4711**	**4894**	**7650**	**9572**	**11050**
Water provider connections outside city limits			1729				
Estimated unincorporated population served	**2473**	**2805**	**3959**	**4053**			
Total population served	**6210**	**6629**	**8670**	**8947**	**11170**	**12632**	**13463**
Exempt wells	494	567	856	877	1123	1270	1353
Persons per exempt well	3.68	3.68	3.68	3.68	3.68	3.68	3.68
Estimated exempt well population	**1818**	**2087**	**3152**	**3227**	**4131**	**4672**	**4979**
Benson Sub-area Population	**8028**	**8716**	**11822**	**12174**	**15301**	**17304**	**18443**

*Includes revised projections from City of Benson Adequacy Designation application to include "Canyons" at Whetstone Ranch. 2030 projection for Benson uses 2.3% annual growth per Benson modification application.
*Projections assume 73% of future population is served by a water provider (based on 2000 percentage); remainder is exempt well population.
*Historic exempt well population based on number of wells and year 2000 person per well.

USP BASIN

	1985	1990	2000	2002	2010	2020	2030
Bisbee city limits	6721	6288	6090	6140	6676	6692	6737
Fort Huachuca	10502	9210	8413	8413	8413	8413	8413
Huachuca city limits	1721	1782	1751	1800	2229	2362	2469
Sierra Vista city limits	18286	23381	29362	32002	37652	43483	47604
Tombstone city limits	1426	1220	1504	1535	1595	1611	1655
Benson city limits	3737	3824	4711	4894	7650	9572	11050
Total incorporated population served	**42393**	**45705**	**51831**	**54784**	**64215**	**72133**	**77928**
Water provider connections outside city limits			5709				
Estimated unincorporated population served	**11161**	**11187**	**14387**	**14108**			
Total population served	**53554**	**56892**	**66218**	**68892**	**74656**	**82332**	**87884**
Exempt wells	1512	1910	3094	3255	3878	4537	5009
Persons per exempt well	4.38	4.41	4.44	4.44	4.42	4.43	4.44
Estimated exempt well population	**6623**	**8426**	**13726**	**14453**	**17136**	**20093**	**22236**
Total Basin Population	**60177**	**65318**	**79944**	**82314**	**91792**	**102425**	**110120**

Data Sources: 1990 and 2000 U.S. Census; 1985 Special Census for Bisbee and Sierra Vista; Putman and others, 1988; ADWR Population Projections (1990-2040) for use in Statewide Planning, August 1993; ADWR Population Projections (1997-2050) for use in Statewide Water Planning Based on May 1997 POPTAC Recommended DES Approved Population Projections, September 1997; 2002 DES Estimates; Arizona Corporation Commission Annual Reports for 2000; Benson Water Adequacy Designation Modification application (No. 21-400351); San Pedro HSR; personal communications.

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APPENDIX J

APPENDIX J

Municipal Population, Water Demand and Water Supply Assumptions

Primary Information Sources

1. U.S. Department of Commerce, Bureau of the Census, 1990 and 2000 Census data.
2. Arizona Corporation Commission, Utilities Division, 2001 and 2003, file data from 2000 and 2002 Annual Utility Reports for Water Companies.
3. Arizona Department of Water Resources, 1991a, Hydrographic Survey Report for the San Pedro River Watershed. Volume 1: General Assessment (San Pedro HSR).
4. City of Benson Designation of Water Adequacy Modification application (No. 21-400351).
5. ADWR Population Projections (1990-2040) for use in Statewide Water Planning, August 1993 and September 1997.
6. Putman and others, 1988.
7. Department of Economic Security, Population Statistics Unit, July 1, 2002 Population Estimates for Arizona's Counties, Incorporated Places and Balance of County Areas, approved December 6, 2002.
8. ADWR 2002c, Well Registration Files.
9. U.S. Army, 2002, Programmatic Biological Assessment
10. Personal communications: M. Apel, Cochise County, 2003; M. Holt, City of Benson, 2002; M. McCarthy, ADEQ, 2003, City of Benson staff, 2004.

Population Estimates

The 1985 population for the entire Basin was determined by subtracting the 1980 Basin population (from Table 2, Putman and others, 1988) from the 1990 Basin population published in ADWR Population Projections (1990-2040) for use in Statewide Water Planning, August 1993, based on Arizona Department of Economic Security (DES) approved projections. The population increase between 1980 and 1990 was divided in half and added to the 1980 Basin population to estimate the 1985 Basin population. The same method was used for incorporated areas, except Benson and Sierra Vista, for which Special Census data were available (Rich Gaar, SEAGO, personal commun., February 2, 2003). Because census data for Sierra Vista includes Fort Huachuca, the 1985 Fort Huachuca population from Table 5-53 of the San Pedro HSR was subtracted from the Special Census data to derive a separate population figure for Sierra Vista.

The 1990 and year 2000 U.S. Census data, by block, were used to disaggregate Census data to the Basin and sub-area boundaries using GIS overlay. Where a block was split by a basin or sub-area boundary, the population in the block was prorated based on the proportion of the area of the block that was included within the boundary. Census data populations were used for incorporated areas for the years 1990 and 2000. The 1990

population of Fort Huachuca was from Table 5-53 of the San Pedro HSR. The year 2000 population was reported by the Fort.

For 2002, the DES approved estimates (12/6/02), were used for incorporated areas and to proportionately adjust the Basin population total from the 2000 census.

A portion of Bisbee's incorporated area lies outside the Basin, however the entire population of Bisbee is included in the report because the water for the incorporated area is withdrawn entirely within the Basin. (The percentage of Bisbee's incorporated area within the Basin was about 66% in 1990 and 69% in 2000).

For 2000, after subtracting the incorporated area population, including the Fort population, from the Basin population, the remaining population is served by private water companies that serve outside of incorporated areas, and individuals on private domestic (exempt) wells. Sierra Vista is served by several private water companies. The town provided information on the number of connections within the incorporated area, which was subtracted from the total connections served by the private water companies, as reported to the Arizona Corporation Commission, to determine the number of connections in the unincorporated area. For the Sierra Vista sub-area, the population in the unincorporated area was determined by multiplying the customer connections by the average persons per occupied household (pphu) figure for the sub-area. The 2000 Census pphu of 2.56 was used.

Census 2000 data was used as a basis for deriving 1985 and 1990 exempt well population and unincorporated population served by water providers in the Sierra Vista sub-area. For 1985 and 1990 the unincorporated population served by a water provider was derived by subtracting the incorporated population and the exempt well population from the sub-area population.

The exempt well population in 2000 was assumed to be the remainder of the sub-area population after subtracting the incorporated area population, including Fort Huachuca, and the unincorporated population served by water providers calculated as described above. The number of exempt wells came from the ADWR Well Registry. By dividing the exempt well population by the number of exempt wells, a person per well number of 4.72 for the Sierra Vista sub-area and 3.68 for the Benson sub-area was derived. This suggests that there are a number of wells serving more than one household. It was assumed that the person per well number is consistent for all years. For 1985 and 1990 the number of wells from the ADWR Well Registry in each sub-area was multiplied by the corresponding person per well number to derive the exempt well population and the remaining unincorporated population was assumed to be served by a water provider.

Population Projections

The Arizona Department of Economic Security develops and approves population projections through a review process by its Population Technical Advisory Committee (POPTAC). New projections are prepared every five years. The most recent projections

approved by POPTAC were prepared and approved in 1997. (ADWR Population Projections (1990-2040) for use in Statewide Water Planning, September 1997).

For the years 2010 through 2030, the 1997 POPTAC approved projections for the Basin and incorporated areas were used with the exception of Benson. Population projections in the application for Benson's Designation of Water Adequacy Modification were used (Application No. 21-400351). The projections for Whetstone Ranch include only Phase 1 of the Canyons Development since a community facilities district had been approved. Phase 1 includes 300 homes, with a total of 1150 homes over a ten-year period. (M. Holt, Benson City Manager, personal comm., 2002).

Fort Huachuca's 2000 population was held constant for projection years because of uncertainties in projecting future base staffing needs. For future years it was assumed that the percentage of the basin population served by a water provider in the year 2000 would remain the same, and that the remaining sub-area population would be served by exempt wells. The Bachmann Springs development northwest of Tombstone is planned as a second-home/resort community and no permanent population was assigned. (M. Apel, Cochise County, personal commun., 2002, 2003)

Municipal Demand

Municipal water provider data in the San Pedro HSR and the 1988 Putman report was reviewed to develop the 1985 and 1990 water use budget for municipal water providers (private water companies and cities and towns). For the year 1990, 1988 data is actually shown. There are slight differences in the data between the two reports but the information is generally consistent. In some instances, information for a particular entity is available in one report but not in the other.

For the years 2000 and 2002, Department staff contacted the Arizona Corporation Commission (ACC) for water delivery or pumpage information for every active private water company in the Basin. Department staff contacted each public municipal system to obtain water use information from those entities.

Water delivered to customers is less than the total water withdrawn from wells due to system losses, accounting errors and miscellaneous uses of water for operations, such as line flushing, that are not metered. Therefore, if pumpage data were not available, a 10% loss estimate was applied to the deliveries by each entity pumping over 250 acre-feet per year, and a 15% loss estimate was applied to the deliveries by each entity that pumps 250 acre-feet or less, to develop a total municipal water provider demand estimate. The loss percentages are based on AMA management plan standards for water systems.

Water provider GPCD rates were calculated for each sub-area by dividing the estimated total water demand by water providers, both private and public, by the population served by those water providers. The year 2000 GPCD rate, including losses and effluent, for each sub-area was used to project the future water provider demand in both areas. In the Sierra Vista area, the year 2000 average GPCD rate was 164 GPCD. For the Benson

area, the figure was 157 GPCD although demand was adjusted to take into account new developments for which individual demand information was available. The GPCD rate was multiplied by the projected water provider population in each sub-area to derive the sub-area water provider demand.

For Fort Huachuca, the information in the Putman report and San Pedro HSR was used for the 1985 and 1990 water production. The 2000 water production was obtained through information provided by the Fort. This demand was held constant, along with the Fort's population, for all projected years with the exception of effluent use on the golf course and parade grounds, as reported in the Fort's Biological Assessment (U.S. Army, 2002). This approach is consistent with that used for water providers, i.e. not assuming future reductions in per capita use rates.

Domestic well demand includes water used for homes, landscaping, small pastures, etc. by wells with a pump capacity of 35 gallons per minute or less. Domestic use was estimated by multiplying the domestic well population in each year by 0.12 acre-foot per person, which is based on large lot use in the Tucson AMA for which a long history of metered water use is available. To this was added demand associated with irrigated lands of less than 2 acres in size based on information in the San Pedro HSR converted to a per person use. The San Pedro HSR lists a total of 572 acres in the Sierra Vista sub-area and 307 acres in the Benson sub-area, each less than 2 acres in size. These acres are assumed to be deficit irrigated using the weighted average consumptive use (CU) for each sub-area described in Appendix G. Because proportionately more small, irrigated lands exist in the Benson sub-area, the acreage per person use estimate differs between sub-areas. The estimated use in the Sierra Vista sub-area is therefore 0.35 af/person and 0.55 af/person in the Benson sub-area.

Municipal Supply

Groundwater is used by all Basin water providers. Groundwater comprises 95% of the municipal water supply in the Basin.

Wastewater treatment plant effluent is used for golf course and other turf irrigation in the Basin. Effluent use by Fort Huachuca is that reported in the Fort's Biological Assessment (U.S. Army, 2002) and 2002 Annual Report. Based on these reports, effluent use at the Fort's turf facilities is projected to decline from 424 acre-feet per year to about 370 acre-feet due to improved irrigation efficiency. This will allow for additional effluent available for recharge.

Benson reported 370 acre-feet of effluent was used to irrigate the San Pedro golf course in 2002 (City of Benson staff, personal commun., 2004). It was assumed that in the future the total volume of effluent generated will be used by the golf course and by other users. ADEQ estimates that Benson generates .48-.53 mgd (M. McCarthy, Arizona Department of Environmental Quality, written commun., 2003). This was averaged, converted to a per capita rate and multiplied by the projected population to estimate future use of effluent.

Surface water is used by the City of Tombstone and is reportedly not separately metered. It is estimated that about 160 acre-feet of surface water is used based on the following information:

1. Putman and others, 1988. Water Resources of the Upper San Pedro Basin, p.25-26
   Average spring use = 156 afa during 1973-1977.
2. Tombstone Watershed File Report. 1985 water use information received from Tombstone Public Works Director 1/86
   Usage from mountain springs = 77mgy or 236 afa (61% of total use)
3. Total water use in 2000 derived by P. Nagel, ADWR, from storage data and population as 248 afa. Assuming 61% is surface water (from #2) = 151 af.

Lacking any predictive information, this estimate was assumed to remain constant in the future.

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APPENDIX K

(K-1, K-2, and K-3)

APPENDIX K-1

USP Basin Water Provider Data for 2002

Benson sub-area Provider	customers	gallons sold	af sold	% lost	gallons pumped	af pumped	Comment
Bachman Springs Utility Co.	0	0	0	0	0	0	not in operation
City of Benson	1174	NR	NR	UK	NR	813	pumpage reported
Crystal Water Co.	52	5,381,340	16.5	15	NR	19.0	pumpage/losses estimated
Dragoon Water Co.	138	10,030,821	30.8	39.2	16,501,000	50.6	
Mescal Lakes Water Sys.	431	26,231,089	80.5	10.3	29,254,000	89.8	
Mustang Water Co.	58	5,049,498	15.5	15	reported same as sold	17.8	pumpage/losses estimated
Pomerene Domestic WUA	339	84,846,683	260.4	10	NR	286.4	pumpage/losses estimated
St. David Water Assoc.	404	NR	188.7	15	NR	217.0	all data estimated*
Sue Juan W.C.	69	14,660	0.04	15	reported same as sold	0.1	pumpage/losses estimated
Sulger Water Co. #2	3	NR	NR	UK	458,388	1.41	pumpage reported
Whetstone Water Improvement Dist.	NR	NR	NR	UK	21,445,990	65.8	pumpage reported
Willow Lakes Property Owners Assoc.	62	5,605,638	17.2	1.3	5,680,530	17.43	
Total sub-area demand w/losses						**1,578**	

Sierra Vista sub-area Provider	customers	gallons sold	af sold	% lost	gallons pumped	af pumped	Comment
Antelope Run W.C.	119	19,372,000	59.5	15	NR	68	pumpage/losses estimated
Arizona W.C. Bisbee	3405	320,002,900	982.1	19.6	398,162,400	1,222	
Arizona W.C. Sierra Vista	2303	396,155,100	1215.8	6.4	423,218,700	1,299	
Bella Vista W.C.	6948	1,104,881,860	3390.8	6.8	1,186,010,000	3,640	
Cloud Nine W.C.	251	NR	NR	UK	12,830,220	39	apparent reporting problems
Cochise W.C.	303	26,632,070	81.7	15	reported same as sold	94	pumpage/losses estimated
Coronado Estates W.C.	168	20,592,850	63.2	0.1	20,622,440	63	% loss questionnable
East Slope W.C.	711	90,527,000	277.8	10	NR	306	pumpage/losses estimated
Holiday W.C.	142	13,211,400	40.5	9.8	14,654,230	45	
Horseshoe Ranch W.C.	190	15,563,630	47.8	15	NR	55	pumpage/losses estimated
Huachuca City	769	NR	NR	UK	81,500,760	250	pumpage reported
Indiada W.C.	49	5,895,020	18.1	15	reported same as sold	21	pumpage/losses estimated
Lucky Hills W.C.	4	257,790	0.8	15	NR	1	pumpage/losses estimated
Miracle Valley W.C.	210	24,073,108	73.9	15	same as sold	85	pumpage/losses estimated
MWC, Inc.	19	NR	NR	UK	1,220,437	4	pumpage reported
Naco W.C.	277	22,646,204	69.5	20.6	28,536,000	88	
Pueblo del Sol W.C.	3725	412,037,950	1264.5	6.7	441,463,100	1,355	
Sierra Vista, City of	4	NR	NR	UK	58,327,329	179	pumpage reported
Southland Utilities Co.	507	46,730,240	143.4	9.1	51,404,000	158	
Stratman W.C.	38	5,389,641	16.5	15	6,191,169	19	pumpage/losses estimated
Tombstone, City of	NR	NR	NR	UK	91,238,280	280	pumpage estimated
Total sub-area demand w/losses						**9,270**	
Basin total demand						**10,848**	

UK = unknown; NR = no record

St. David Water Association did not submit an annual report to the ACC for 2001-2003. Estimates based on data from 1988, adjusted for growth between 1988 and 2000.

Huachuca City data from Billy McClain. Tombstone data from 2000. Private water company data from Arizona Corporation Commission 2002 Annual Reports.

Where pumpage data unavailable, delivery data adjusted to include system losses; 10% for large providers and 15% for small providers.

"Large providers" pump more than 250 acre-feet per year. "Small providers" pump 250 acre-feet or less per year.

APPENDIX K - 2
Sierra Vista Sub-area Water Provider Data for 1985, 1990 & 2000

SIERRA VISTA LARGE PROVIDERS	1985 Use acre-feet	1985 customers or population	1990 (1988) Use acre-feet	1990 (1988) customers or population	2000 Use acre-feet	2000 customers or population	2000 Pop.	2000 GPCD w/o losses	Estimated(E) or Data(D)
Arizona Water Company Bisbee	1,137	4,517	962	6,288	1,003	6,090	6,090	147	E
Arizona Water Company Sierra Vista	779	1,776	862	2,007	1,109	2,253	5,903	168	E
Bella Vista Water Company	2,870	3,519	2,907	5,843	3,208	6,674	17,486	164	D
Cloud Nine Water Company	40	63	44	265	271	251	658	368	D
East Slope Water Company	147	486	176	543	253	675	1,769	128	D
Huachuca City	180	1,721	268	1,782	263	1,751	1,751	134	E
Pueblo del Sol Water Company	219	NR	360	1,114	1,136	3,335	8,738	116	D
Large provider total use	**5,372**		**5,578**		**7,243**			**153**	
Large provider total population		**27,616**		**32,938**			**42,394**		
Large provider total demand	**5,968**		**6,198**		**8,048**				
Large provider total GPCD w/losses	**193**		**168**		**169**				

SIERRA VISTA SMALL PROVIDERS	1985 Use acre-feet	1985 customers or population	1990 (1988) Use acre-feet	1990 (1988) customers or population	2000 Use acre-feet	2000 customers or population	2000 Pop.	2000 GPCD w/o losses	Estimated(E) or Data(D)
Antelope Run Water Company	1	4	4	10	46	104	272	152	D
Cochise Water Company	14	50	NR	NR	57	256	671	76	D
Coronado Estates Water Company	28	104	NR	NR	61	160	419	129	D
Holiday Water Company	23	89	23	92	37	130	341	97	D
Horseshoe Ranch Water Company	7	35	13	45	43	178	466	82	D
Houghland WC	9	15	NR	12	NR	NR	NR	NR	NA
Indiada Water Company	8	29	8	35	18	47	123	130	D
Lucky Hills Water Company	2	3	0	4	1	4	10	73	D
Miracle Valley Water Company	43	113	40	117	66	187	490	121	D
Naco Water Company	67	231	72	253	82	349	914	80	D
Nicksville Water Company	30	136	34	143	part of Bella Vista				
Palominas Development Company	NR	NR	NR	NR	NR	NR	NR	NR	
Ranch WC	7	NR	NR	NR	NR	NR	NR	NR	
Santa Cruz Water Company	NR	18	NR	NR	not in operation				
Sierra Vista, City of	5	NR	169	NR	178	4	NA	NA	D
Southland Utilities Company	81	342	100	415	121	492	1,289	84	D
Stratman Water Company	1	5	4	12	18	38	100	161	D
Tombstone, City of	206	1,135	NR	1,289	249	1,504	1,504	54	E
Small provider total use	**532**		**468**		**977**			**132**	
Small provider total population		**4,328**		**4,384**			**6,600**		
Small provider total demand	**625**		**551**		**1,149**				
Small provider total GPCD w/losses	**129**		**112**		**155**				
Total sub-area population served*		**31,944**		**37,322**			**48,993**		
Total sub-area demand w/losses	**6,594**		**6,749**		**9,197**				
Total sub-area GPCD	**184**		**161**		**168**	**Year 2000 total GPCD w/losses**			

NR = no record; NA = not applicable. 1990 use is actual 1988 from the San Pedro HSR. *Total water provider population does not correspond to populations listed in Appendix I since individual provider populations were not always available. See Appendix J for details. Private water provider data from ACC records. Delivery data adjusted to include system losses; 10% for large providers (pump >250 af/yr) and 15% for small providers (pump 250 af/yr or less). Bisbee 2000 use based on 2000 Census population and ave. basin GPCD. Cloud Nine W.C.reporting inconsistencies noted. Huachuca City 2000 use based on 2000 Census population and 1990 GPCD. Tombstone 2000 use estimated from storage tank data and 2000 Census population.

APPENDIX K - 3

Benson Sub-area Water Provider Data for 1985, 1990 & 2000

BENSON PROVIDERS

	1985 Use acre-feet	1985 customers or population	1990 (1988) Use acre-feet	1990 (1988) customers or population	2000 Use acre-feet	2000 customers or population	2000 Population	2000 GPCD w/o losses
Anderson Water Company	NR	NR	NR	NR	not in operation			
City of Benson	604	3,494	545	3,824	728	4,711	4,711	138
Crystal Water Company	3	11	NR	NR	14	47	108	115
Dragoon Water Company	NR	NR	NR	NR	28	132	302	82
F & F Water Company	NR	NR	NR	NR	NR			
Konen Water Company	NR	NR	NR	NR	not in operation			
Mescal Lakes Water Systems	12	65	25	147	69	408	934	66
Mustang Water Company	7	31	NR	NR	15	53	121	114
Pomerene Domestic Water Users Assoc	118	171	127	184	229	290	664	308
St. David Water Association	103	276	125	319	180	392	898	179
Sue Juan Water Company	62	63	61	67	0	71	163	0
Sulger Water Company #2	NR	NR	NR	NR	3	3	7	422
Whetstone Water Improvement District	8	NR	NR	NR	57	275	630	81
Willow Lakes Property Owners Assoc.	7	28	10	31	12	58	133	78
Total sub-area use	**925**		**893**		**1,335**			
Total sub-area population*		**5,152**		**5,746**			**8,670**	
Total sub-area demand w/losses	**1,048**		**1,015**		**1,523**			
Total sub-area GPCD	**182**		**158**		**157**	**Year 2000 total GPCD including losses**		

NR = no record
1990 use is actual 1988 data from the San Pedro HSR
*Total water company population does not correspond to populations listed in Appendix I since individual provider populations were not always available. See Appendix J for details.
Private water provider data available from Arizona Corporation Commission records. City of Benson data from published reports or provided upon request
Delivery data adjusted to include system losses; 10% for Benson (large provider estimate) and 15% for all others (small provider estimate).
Large providers pump more than 250 acre-feet per year. Small providers pump 250 acre-feet or less per year.

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APPENDIX L

APPENDIX L

Industrial Water Demand and Supply Assumptions

Primary Information Sources

1. Arizona Department of Water Resources, 1991a, Hydrographic Survey Report for the San Pedro River Watershed. Volume 1: General Assessment (San Pedro HSR).
2. Water Resources of the Upper San Pedro Basin, Arizona, 1988, Putman and others.
3. Aggregates Manager, Volume 5, #11, February 2001.
4. Arizona Department of Water Resources, Santa Cruz AMA Third Management Plan, 2000-2010 and Tucson AMA Third Management Plan, 2000-2010, 1999 a,b).
5. Personnal communication: N. Niemuth. Arizona Department of Mines and Mineral Resources 2002, P. Bielke, Apache Nitrogen Products, 2003, R. Darling, Pueblo Del Sol Water Company, 2003).

Industrial Demand

Industrial demand is defined in the Groundwater Code as a "non-irrigation use of water not supplied by a city, town or private water company…". A.R.S. § 45-561(4). Industrial users identified in this report are those that would potentially be regulated if the Basin were to be designated as an AMA (see Chapter 6 for specific information). Industrial water demand in the Basin consists of an estimated 5 sand and gravel facilities, one dairy, an ammonium nitrate manufacturing plant, and 3 golf courses supplied water from their own well(s).

Sand and Gravel Facilities

Data on historic sand and gravel operations were available from the San Pedro HSR. Information on the number of currently operating sand and gravel facilities was obtained from Aggregates Manager, Volume 5, #11, February 2001 that listed Arizona sand and gravel facilities by county with a corresponding map. The facilities reported that are within the Basin are Huachuca Concrete, Young Block, Granite Construction and Peter Kiewit and Sons. One of these may now be Metro Material. An additional small facility was observed in January 2003 just south of Hereford Road, approximately one mile east of Nicksville. All facilities are located in the Sierra Vista sub-area.

Water demand data was not available, despite attempts to contact facilities directly. Because sand and gravel operations are associated with population growth and construction, a per person approach was used to estimate their water demand. Actual demand of each of the operating facilities was available for 1985 and 1990 (1989, actual) from the San Pedro HSR (pages 362 through 364 and 372 through 374). A per person estimate was derived from the relationship between population growth and water demand

by the sand and gravel facilities and this was used to estimate demand in current and projected years. This estimate is .201 acre-feet per person added per year. However, because of the large degree of uncertainty involved and likely annual fluctuations, these estimates were then averaged to project use. Therefore, an annual demand of 214 acre-feet for all sand and gravel facilities was assumed as shown in Table L-1. In AMAs, only sand and gravel facilities that use more than 100 acre-feet per year are regulated.

Table L-1. Sand and Gravel Facility Water Use

Year	Basin Population	Growth	Avg./Yr	Sand & Gravel Use (af)	Data Source
1985	60,177			187	actual, (San Pedro HSR)
1990	65,318	5,141	1028.2	207	actual, (San Pedro HSR)
2002	82,314	16,996	1416.3	285	projected
2010	91,792	9,478	1184.8	238	projected
2020	102,425	10,633	1063.3	214	projected
2030	110,120	7,695	769.5	155	projected
			AVG:	**214**	

Note: For 1990, the volume of water used by all sand and gravel facilities was equivalent to .201 acre-feet per person added per year. This was used to estimate the sand and gravel demand in other years.

Dairy Operations

In 2002 there was one dairy located north of Pomerene. At a meeting held at the Natural Resources Conservation District office in Benson in January 2002, the dairy was reported to be a 350-head operation. The dairy's water demand was estimated by multiplying 105 gallons per lactating animal per day by 350 animals. Although there are typically also non-lactating animals on dairy sites, it was assumed for this review that all animals were lactating. The demand of 105 gallons per day is the water use allocation for lactating animals for dairies regulated under the Third Management Plan (TMP) for the Tucson AMA. Total water use was therefore estimated to be 41 acre-feet in 2002 and this use was assumed in all projection years.

Large-Scale Cooling Facilities

A facility that has control over cooling operations with a total combined cooling capacity greater than or equal to 1,000 tons is defined as a large-scale cooling facility (Tucson AMA TMP). Cooling capacity tonnage indicates the rate at which the cooling tower can reject heat. The Apache Nitrogen plant fits this definition, with four cooling towers on site - 2 at the nitric acid plant and 2 at the powerhouse (P. Bielke, Apache Nitrogen Products, personal commun., 2003).

- Nitric acid plant cooling towers:
  AOP3 = 4,900 tons
  AOP4 = 5,833 tons
  Total = 10,733 tons
- Powerhouse cooling towers:
  2 towers, each 700 tons
  Total = 1,400 tons

Water use data at Apache Nitrogen was obtained from the San Pedro HSR for 1985 and 1990 (1989 actual). After 1990, Apache Nitrogen implemented a number of water conservation measures that resulted in substantial water use reductions. Current (2001) use was provided by the facility. Water use in each of these years is shown in Table L-2. Projected water use was assumed to remain at 2001 levels for all projected years.

Table L-2. Water Use at Apache Nitrogen

Year	Water Use (acre-feet)
1985	331
1990	542
2001	288

Turf-related Facilities (Golf courses, parks, schools, cemeteries, etc.)

ADWR identified golf courses and other turf-related facilities (facilities with ten or more acres of water-intensive landscaping) through reports, interviews and satellite imagery. There are three industrial turf-related facilities, all golf courses, in the Basin; Turquoise Hills Golf Course in the Benson sub-area and Turquoise Valley and Pueblo del Sol Golf Courses in the Sierra Vista sub-area. Turquoise Hills expanded from a nine-hole course, with a reported demand of 127 acre-feet in 2000 to an 18-hole course, with an estimated demand of 500 acre-feet per year in 2002. The demand for Turquoise Valley Golf Course of 577 acre-feet/year is from the Wastewater System Improvements Project Environmental Assessment, City of Bisbee (EPA) 2003. The demand by Pueblo del Sol Golf Course was assumed to be 500 acre-feet per year of which 5% is served by Pueblo del Sol Water Company (R. Darling, Pueblo Del Sol Water Company, personal commun., 2003).

The regulatory target for new golf courses in the Santa Cruz AMA, an area with similar climate to the Upper San Pedro Basin, is approximately 428 acre-feet per year. However, the average usage by established golf courses ranges from about 470 acre-feet to almost

550 acre-feet in the Santa Cruz AMA. Therefore, 500 acre-feet of annual water use was assumed to be a reasonable estimate for an established golf course. Historic and projected demand by industrial golf courses is shown in Table L-3.

Table L-3. USP Basin Industrial Golf Course Historic Demand and Projections (golf courses not served by a city, town or private water company)

Year	Sierra Vista sub-area (acre-feet)*	Benson sub-area (acre-feet)**	Total	Number and size of Golf Courses
1985	975	127	1102	9-hole in Benson, two 18-hole in SV
1990	975	127	1102	9-hole in Benson, two 18-hole in SV
2002	1052	500	1552	18-hole in Benson, two 18-hole in SV
2010	1052	500	1552	18-hole in Benson, two 18-hole in SV
2020	1552	500	2052	18-hole in Benson, three 18-hole in SV
2030	1552	500	2052	18-hole in Benson, three 18-hole in SV

* In the Sierra Vista sub-area, there were 3 golf courses in 2002 and 4 projected by 2020. Two, Turquoise Valley and Pueblo del Sol, are industrial. An additional industrial course is projected. There is one municipal golf course, Mountain View, served effluent by Fort Huachuca. Pueblo del Sol Water Company serves about 5% of the Pueblo del Sol Golf Course demand. No new industrial parks or schools with over 10 acres of turf are projected.

** In the Benson sub-area, there were 2 golf courses in 2002 and 3 projected by 2030. Only one, Turquoise Hills, is industrial. It was expanded from 9-holes to 18-holes in 2002. One municipal course is served 100% effluent by Benson. A projected municipal course is assumed to be served by a Bachmann Springs development water company. Any golf courses at Whetstone Ranch assumed to be municipal.

Industrial Supply

In both sub-areas, groundwater is currently the only industrial water supply. By 2010 it is projected that 570 acre-feet of effluent will be delivered to the Turquoise Valley Golf Course according to the preferred option in the Bisbee WWTP consolidation Environmental Assessment (EPA 2003).

APPENDIX M

APPENDIX M

Summary of AMA Practices and Effects

AMA Practice	Effect of AMA Practice
Groundwater Rights and Permits	
Quantifies and caps the maximum amount of annual withdrawals possible from non-exempt wells for agricultural and some industrial uses. Municipal water use not capped because service area rights lack a volumetric groundwater withdrawal limit and new service area rights can be established. Groundwater withdrawal permits can be issued for specific purposes if certain requirements are met. Permits are issued for a specified time period and are quantified.	Approximately 22,500 acre-feet of water use in the Basin, or 72%, could be eligible for a water right and subject to water rights requirements, metering and payment of fees (excludes exempt wells, Fort Huachuca and facilities using 100% non-groundwater supply).
Metering and Reporting	
Non-exempt wells must be metered. Deliveries in most cases must also be metered. Annual water withdrawal and use report required from water rights holders.	Wellhead meter cost is approximately $500 plus maintenance and energy costs. Would only apply to wells equipped with pumps having a pump capacity over 35 gpm. Provides information on regional and local groundwater use and trends in demand. Where deliveries or points of use measurements are required, metering allows calculation of lost and unaccounted for water.
Groundwater Withdrawal Fees	
Holders of most water rights and permits must pay an annual per acre-foot fee. Holders of Type 1 and Type 2 grandfathered groundwater rights and groundwater withdrawal permits pay a WQARF fee of $2.12 per acre foot of water used to fund the cleanup of hazardous substances.	The withdrawal fee for service area rights is levied on the water provider and could result in a very slight increase in water bills. Economic impact potentially greater for other rights holders depending on amount of fee. WQARF fee would be an additional expense for holders of Type 1 and Type 2 groundwater rights and groundwater withdrawal permits.

Refer to Chapter 6 for details on AMA practices and effects

AMA Practice	Effect of AMA Practice
Wells	
Water withdrawals from a non-exempt well requires a legal authority, metering and reporting. Drilling most non-exempt wells requires a well impact analysis that demonstrates no unreasonable impacts to surrounding wells. Water withdrawals from new exempt non-residential wells drilled after April 28, 1983 cannot exceed ten acre-feet per year. Restriction on more than one exempt well serving the same purpose at the same location. Exempt wells may not be linked together by a pipeline (doing so would circumvent the need for a water right).	Drilling new large wells would be subject to metering and reporting not currently required. A well impact analysis provides some protection to existing well owners and could affect the siting of new large wells. Limits on groundwater withdrawals by exempt non-residential wells could limit some uses. Would limit maximum volume of water withdrawn at the same location for the same use. Would require sufficient production and/or storage from individual wells for intended purpose. Could restrict development and use in areas with insufficient supplies.
Agricultural Land Development Restrictions	
No new agricultural land can be irrigated, with limited exceptions.	No general agricultural expansion currently occurring in the Basin. Would prohibit moving farming operation to a new location.
Management Plan: Agricultural Conservation Program	
Water duty allotment or best management practices program, reporting and metering for irrigated acreage greater than 10 acres in size. Canal efficiency standards for irrigation districts.	Would require irrigation efficiency (consumptive use would not be affected) and possible financial investments. Delivery systems appear to be meeting standards. Assuming all users use some groundwater, conservation requirements would apply to 3,000 acres of land.

Refer to Chapter 6 for details on AMA practices and effects

AMA Practice	Effect of AMA Practice
Management Plan: Municipal Conservation Program	
Per capita and distribution system requirements for systems >250 acre-feet; general conservation and distribution system requirements for smaller systems. Best management practices programs alternative. Under the GPCD program, actual implementation of conservation programs is discretionary; the goal is per capita use. Deliveries must be metered.	Per capita conservation requirements would apply to about 47% of the municipal water use. Small systems, exempt wells and Fort Huachuca not affected. Could result in some reductions; likely less than 10% based on results in existing AMAs. Financial investments in fixing system leaks, conservation and metering possible.
Management Plan: Industrial Conservation Program	
Allotment limits for turf-related facilities (golf courses, parks, schools etc. over 10 acres in size) and dairies. Best management practices programs with no allotment for regulated sand and gravel facilities, metal mines and dairy facilities upon application to the dairy BMP program. Large-scale cooling towers must achieve specific concentrations of silica or total hardness in the recirculating water before blowing down. All industrial facilities would be subject to metering, annual reporting and the basic industrial user requirements, e.g. reuse, recycle, limit single-pass cooling. Facilities using 100% effluent are exempt from requirements.	Because of effluent use and facility size regulatory limits, estimated that a dairy, 4 cooling towers and 4 turf-related facilities would be subject to conservation requirements. Affected volume approximately 2,100 acre-feet. Potential savings believed small. New turf-related facilities would receive more rigorous conservation allotments that effectively limit the number of turfed acres. Implementation of conservation requirements could require investments in conservation technologies, metering and more efficient water management.
Management Plan: Augmentation and Recharge Program	
No mandatory requirement to use or store renewable water supplies, only incentives and financial assistance. The only supply currently available for augmentation is effluent.	Incentives could promote recharge but current plans are that 95% of available effluent will be recharged or used directly in 2030.
Management Plan: Groundwater Quality Program	
There are some regulatory program incentives to use poor quality water and reuse wastewater.	There is limited poor quality water for use. Management plans would contain an assessment of Basin water quality conditions.

Refer to Chapter 6 for details on AMA practices and effects

AMA Practice	Effect of AMA Practice
Management Plan: Water Management Assistance Program	
Portion of withdrawal fees goes towards user assistance in meeting conservation requirements, for augmentation and for monitoring. Local Groundwater User Advisory Council sets fee amount and how it should be allocated.	Program would supply additional funding for conservation programs, aquifer monitoring and augmentation projects. Program would provide benefits to regulated water users.
Assured Water Supply Program	
New subdivisions must have a Certificate of AWS or be served by a water provider with a Designation of AWS. Requires: Physical, legal and continuous water availability for 100 years; compliance with water quality standards; financial capability to construct the delivery system and related features; consistency with the AMA's management plan; and consistency with the AMA's management goal (requires use of a non-groundwater supply to meet the goal).	Only new subdivisions would require an AWS demonstration, equivalent to an estimated 8,300 acre-feet of required renewable water supply use in 2030. Limited renewable supplies. Irrigation, Type 1 and Type 2 grandfathered rights could be retired for AWS credits, reducing allowable pumping volume in basin. Could promote importation. Using effluent to meet AWS replenishment requirements would mean storing and recovering (pumping) it. Using surface water to meet AWS replenishment requirements is an option; requires perennial source or sufficient backup and a surface water right. Increased development costs. Possible less development.
Groundwater Transportation	
Transportation of groundwater into or outside of the Basin prohibited. Groundwater could be transported within the Basin. Groundwater could be transported between sub-basins subject to payment of damages in most cases.	No impact. Same restrictions currently exist.

Refer to Chapter 6 for details on AMA practices and effects